McGivern, James Gregory
1932

A course of study and a Teacher's manual for a thirty-lesson course in engineering drawing.

BOSTON UNIVERSITY

SCHOOL OF EDUCATION

Thesis

A COURSE OF STUDY AND A TEACHER'S MANUAL FOR A THIRTY-LESSON COURSE IN ENGINEERING DRAWING

Submitted by

James Gregory McGivern

(B.M.E. Northeastern Univ. 1928)

In partial fulfillment of requirements for the degree of Master of Education

1932

First Reader Arthur W. Weysse, Dean, Graduate School

Second Reader Herbert Blair, Professor, School of Education

PREFACE

The writer wishes to take this opportunity to thank Dr. Arthur W. Weysee, Dean of the Graduate School of Boston University for the guidance rendered by him in the preparation of this thesis.

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

List of Illustrations

CHAPTER I

Statement of the Problem

The purpose of this thesis is to give the instructor, in workable form, those instruments used by him in the practice of his profession. His first concern is what instrument am I to use? We reply by giving him a course of study. His next question is how am I to use it? We immediately present him with a teacher's manual giving him directions how to use the course of study. He being of an inquisitive type of mind inquires how am I to know that out of possibly a hundred possible instruments you have passed me the correct one? We say, "Before you were presented the instrument a history of the case was reviewed with a final statement of the present-day condition of the subject used as the basis for our judgment." He asks as a final question, how, if I use the given instrument in the manner perscribed by the manual, can I tell that the results will be due to my efforts or to natural causes and whether they will be consistant with the defined objective? That question was anticipated by including in the last division of the thesis techniques to be used for measuring both aptitude for, and achievement in, the subject of engineering drawing.

The engineering drawing course refered to is to be taught along with mathematics and physics as the first year subjects on a four year semi-professional evening engineering school curriculum. The work we are undertaking is justifiable

when we consider that mathematics and physics are taught to provide background for more advanced professional work, while engineering drawing, although a preparation of further study, can stand on its own feet as a unit in itself, and offers the student his first contact to what he considers the realities of engineering. It is this function of offering the proper orientation to the engineering curriculum that makes it necessary that the teaching of drawing be of the best.

It is to be hoped that in completing the task we have set for ourselves there will be evolved many values of an indirect nature. These values will consist of gaining a greater acquaintanceship with the literature and practices of engineering drawing as well as obtaining a familiarity with the current educational practices as they affect the content, organization, methods of teaching, and measurement of the subject.

It is with this purpose of fulfilling a definite need, learning new educational principles and practices, and applying others already acquired to the subject of engineering drawing, that we will start on the main body of our work and concern ourselves with the objectives of the course of study.

CHAPTER II

Objectives of Engineering Drawing

In attempting to define the objective of any course of study, our first thought would be to recall to mind the, "Seven Cardinal Prinicples of Education," and then to examine the subject under discussion to attempt to tie that subject up with some one or several of the cardinal principles. In order that we shall not be carried astray, it is well to remember that the Cardinal Principles are objectives that are very general in their nature and contain the desirable outcomes that are to be engendered by the complete educational process, and not alone by any one particular subject. In considering this one subject, I think it would first be well to review a little of the development of the science in order that we may see it, not as a static unit apart from other subjects, but, as a dynamic subject interrelated with other subjects and having aims and objectives that have been fashioned out of long experiences and at the same time adaptable to present-day practicès. This investigation would logically lead us to a statement of the ultimate aims of drawing, but in attempting to formulate in understandable terms the objectives of the course I think it will be much clearer if we divide the topic into two parts; first, the general and ultimate aims; and, secondly, the specific aims. With this in mind, we will proceed first for a clear statement of the ultimate or general aim of our course in drawing.

Although the Greeks used horizontal projections, which they called ichnography and vertical projections, called orthography as well as knowing something of perspective, drawing, as a science, is very generally conceded to begin with the Gaspard Monge, a French Army Officer, who, in 1795, published his book on the new subject of "Descriptive Geometry," which he, at the same time, introduced into the curriculum of the Ecole Polytechnique. This subject treats with the abstract theory of Engineering drawing, and even today has a place in the curriculum of both the secondary and advanced schools of Europe. Monge in his text stated that descriptive geometry has two objectives; the first, to give the methods of representing on a sheet of paper which has only two dimensions, the shape of a body which has three. The second, to recognize from an exact description the form of a body and all the truths about it. In addition to these two objectives of the science he went further and justified the study on the basis of its training in exactness, a characteristic he thought to be lacking in the French people. It has been this last reason, which is largely one of mental discipline, that has been the justification of the study in the non-engineering schools of Europe up to the present day.

The applications of the study were practically without exception, limited to military engineering so that it is only natural that the subject should be introduced into this country through West Point. The first text on the subject

written in English by Crozet, was published in 1821, and he stressed as its objective its use in solving graphically, problems in machine design, bridge design and other engineering problems whose analytical solutions were very laborious. He also stressed its value in strengthening the imagination.

Charles Davies, who succeeded Crozet at West Point published a book in 1836 in which he gave the objectives of the subject in the following sentence: "The useful and important results to which it leads, mutual dependence of its parts, and the concise and satisfactory reasoning in the development of its principles, recommend this study, as well to the practical man, who learns only what he can successfully apply, as to the lover of science, who explores all its departments in search of new facts and interesting truths." It is easily seen that he justified the subject as much for its method of reasoning as for its usefulness.. As we get nearer to our own day, we see that the original subject has been divided into Engineering Drawing justified principally for its usefulness and the other, still retaining the name of Descriptive Geometry, justified mainly on the principle of the mental discipline that it renders.

Having in mind the objectives of the pioneers in the subject of Descriptive Geometry and that later the original subject was subdivided, the practical side being termed Engineering Drawing, or Mechanical Drawing, as it is sometimes called, it will now be of interest to see how far

astray some of the present-day thinking and practice of Engineering Drawing, are from those of the original thinkers in the field of Descriptive Geometry.

There seems to be a great difference of views concerning the aims and objectives of Engineering Drawing, but in general they may be classified under the industrialist's point of view and the educationalist's view point. The industrialists have controlled this subject more than the rest on the curriculum because it has more immediate, practical usefulness, and has been taught by graduates of technical schools and colleges who, although well grounded in subject matter have not had adequate teacher training. The principal error that the industrialists have made is to base their aim on the local industries and to state that the sole objective of the course is to make draftsmen. The first statement is unsound because the course should be general enough in character to provide a knowledge of the fundamentals of projection that would enable a boy to enter any type of industry with a good prospect of making progress. That all the students should be trained to be draftsmen is as nonsensical as to suppose that all students studying mathematics are preparing to become professional mathematicians.

In a questionaire sent out by Professors Thomas E. French, and Carl L. Svensen to the high schools of Ohio in 1919, they received the following answers to the question:

"What do you consider as the object of Mechanical Drawing in your school?"

1. "To learn to read a drawing and to become a draftsmen.

2. To make drawings of simple parts.

3. To read blue prints.

4. To make draftsmen.

5. To get as much college credit as possible.

6. To train for accuracy.

7. To learn the graphic language.

8. I consider it an important part of secondary education. It strengthens the imagination, from habits of accuracy and careful observations.

9. This forms a part of their general education. We do not aim in our school to turn out tradesmen as yet."

The first four of these answers have the point of view of the industrialists and it is entirely possible that they were expressed by those teachers connected with vocational departments of the high schools. The remaining have a more or less worthwhile educational point of view while only number eight gives evidence of there being much thought given to the question.

The following quotations are included to give the variety of points of view that are accepted as the objectives for actual courses of study in use.

Quoting from the Special Syllabus in Art for the Boston High Schools. "The aim of the course is to teach thoroughly the elements of the subject with special attention to the

progressive application of fundamental principles."

The following list of objectives is taken from a course of study used in the Lynn public schools.

1. To present mechanical drawing as the language of the industries.

2. To develop good habits in planning and executing.

3. To teach how to make usable sketches and working drawings.

4. To teach how sketches, working drawings, plans, blue prints, etc., are made and used in the arts and industries.

5. To teach how to read sketches and working drawings.

6. To develop the power of visualization.

7. To present drafting as a pre-vocational or try-out course.

8. To present problems requiring the application of some of the principles learned in arithmetic.

9. To teach the proper use of the instruments, the materials used in mechanical drawing and the fundamentals of mechanical representation.

Professor Carl L. Svensen makes the following statement: "The elementary Mechanical Drawing is intended to give a student sufficient practice in the use of instruments, lettering, sketching, and in making drawings, using the principles of orthographic projection so that he will make neat, readable working drawings or tracings of models, or of machine parts.

[illegible]

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. [illegible]
7. [illegible]
8. [illegible]
9. [illegible]

[illegible]

The various points of view presented in an attempt to formulate the ultimate objective of our course show the wide variety of objectives that are adhered to in teaching practice. Some of these differences are justifiable, but at the same time many give positive evidence of loose thinking as they confuse the objectives with the outcomes and in many cases with the course content.

Before tieing ourselves down to a final statement of the ultimate aim it is well to consider that this ultimate aim should be general enough in character to allow for individual differences among the students. Although allowing for them, it would probably not be definite enough to state specifically those particular differences. This will necessitate a statement of specific aims in order that the instructor will have something concrete in meeting individual needs in drawing. These differences may be stated as being due to the following factors:

Variations in native capacity of the students.
Variations in purposes of the students.
Variations in economic opportunities of students.

That difference due to the intelligence or native capacity of the students, is, of course, present in all other subjects and must be recognized by all progressive teachers. There is another angle to which a fuller discussion will be given later, and that is the question as to whether our course, which requires a high degree of visualization, does not call into play

a special ability for which a special type of test must be devised as an aid for proper guidance. This difference should not affect the course of study as much as the method of teaching.

Variations in purposes of students affect to a large degree their interest in the subject, which, if favorable, the teaching becomes motivated largely due to the pupils' interests. This again becomes a factor in the method of teaching, rather than affecting the course content to a very marked degree. In considering a course of study for a high school this factor materially does affect the objective and course of study, but in our problem, where we are concerned with a semi-professional type of engineering school, this factor takes care of itself.

The economic aim that prompts any individual to attend a professional school is one from which the student feels that for the time and money he invests at school he will receive a large return on his investment in the future. This aim strips the course of study down to the essentials in order that the maximum benefit may be obtained from the course in the given time. It also emphasizes skill and speed in drawing as important outcomes of the course.

Having in mind that the above specific aims are to be allowed for, we are now ready either to formulate or accept a statement, that has already been drawn up, concerning the ultimate aim of our course. In as much as our course is to be a foundation course for more advanced engineering work,

[illegible]

and in so far as the time element in the course strips it of most of the theory originally studied under the name of Descriptive Geometry, I think we will do well to accept the Report of Committee Number One on the aims and purposes of Engineering Drawing who make the following statement:

The aims and objectives of an engineering course are both cultural and utilitarian in nature. The student should receive such training in the theory and practice of engineering drawing, as will enable him to grasp the fundamental principles of the graphic language with which he may solve the problems of modern engineering.* The committee then proposes measures for the accomplishment of those aims which concern the course of study and method of teaching, factors that will engage our attention at a late point in our discussion.

* Committee appointed by the division of Engineering Drawing of the Society for the Promotion of Engineering Education and submitted its report in June 1930, at the summer meeting of that division at Pittsbury, Pennsylvania.

CHAPTER III

Need of a Course of Study and a Teacher's Manual

The weaknesses to be observed in teaching may be classified under those that are professional in character, and those that are of a personal nature. Those weaknesses that are professional in character may in a large measure be remedied by a proper defining of the aims and objectives, setting up a course of study in terms of those objectives, giving methods by which the course contents may be effectively taught, and setting up procedures by which the outcomes may be measured consistent with the objectives of the course.

A The Fulfillment of Objectives

It would seem logical then that after having rather definately set up the objectives of our course of study, the next step would be to concern ourselves with a selection of activities and subject matter by which our objectives may be realized. If we would but recall for a moment the many points of view that were included in the list of objectives, of drawing courses, that we considered, it is easily seen that each point of view would require a different course of study for its proper fulfillment. That the course of study is a great help in the fulfillment of objectives, I think we will all agree but that the course of study in itself is enough to ensure that the outcomes are consistent with the objectives is not always true and upon this point there is not an

agreement of opinion. This is caused by the fact that many teachers and school administrative officers do not recognize the difference between abilities to be acquired and the learning exercies to be done as a means of acquiring these abilities. The following illustration will bring out the fact that to prescribe a set list of exercies to be done by students in a definite period of time is no assurance that upon the completion of those exercises they will all have had the opportunity to acquire the same information, attitudes or skill.

In the following case we will consider the teaching of a geometrical construction that is included in a typical course of study. Assume that three students have completed the problem under three different instructors. The first teacher may be of the drill type with the result that the student learns the particular solution to the extent of being able to repeat the construction habitually, while the second student under a different teacher has learned the mathematics of the construction without associating it with the graphical solution. The third student, under a third teacher, may have been directed toward the proper analysis of any geometric construction problem, with this particular problem as an illustration. This reflective attitude would then carry over to other construction problems.

The case of three different instructors using the same problem to develop three different types of abilities will

serve as a basis for the conclusion that the course of study is very important in setting up the proper situation for carrying out of the objectives, but without the teacher's manual we are not ensured that the outcomes of the set situations will be the desired ones.

<u>B</u> <u>Proper Perspective</u>

A course of study is of great aid in giving the instructor, at the outset, a proper perspective on the complete work to be covered. He then looks at the work as one continuous teaching performance, each part depending on each other part. This most favorable attitude is further strengthened by having a teacher's manual which with its lessons planned out fuses the properly arranged course outline with the techniques employed for teaching. It also combines the classroom organization and measurement into one harmonious teaching program consistent with the objectives of the course.

To the instructor who teaches drawing in the day time with a different objective in view and with a different time distribution the course of study automatically eliminates the less important subject matter and so organizes the work that the instructor can see the subject adapted to the condition at hand, and put the greater part of his effort on teaching rather than organizing. For the part-time evening school instructor who is engaged in engineering practices as his regular work the course of study and teacher's manual gives him a proper perspective of the subject. This is very

[illegible]

[illegible]

[illegible]

important as many of this class of instructors are very apt to be unfavorably influenced by their own particular experiences as to the relative importance of certain parts of the work.

C Aid for Improving Teaching Technique

In considering the merits of a course of study and a teacher's manual as an aid for the improvement of teaching techniques it would be well at this stage to state in a general way at least just what some of these techniques are. In doing this we will define our terms and establish concepts that will give us a common basis for a discussion. It will also supply the necessary back ground for the choosing of a specific method of teaching; that is, to apply directly to our course, and to be taken up more definitely in another chapter of this thesis.

The word teaching technique may be applied to two types; the first being very general in character and known as the major technique. Under this division comes the recitation, the problem, the laboratory, the lecture, and the project. For the accomplishment of any one or combination of these major techniques several or more so-called minor techniques, such as questioning drill, reviews, appreciation, assignments and measurement need be employed. In order that we associate definite meanings when we speak of these terms, which are so often loosely used, the following explanations are in order. We will consider then in the order previously stated, first the major and then the

minor techniques. As our interest is confined to Engineering Drawing, our explanation will consider these terms as they would be used in our work.

By recitation is meant a teaching exercise having a definitely scheduled time and place, and in drawing has as its chief purpose providing the students with a correct and thorough understanding of the principles of projection rather than training in drawing technique such as the proper use of the instruments and the betterment of line work. This purpose is accomplished by means of explanations, questioning, demonstrations, problem solving and quizzing. The fact that this exercise must have a definitely scheduled time and place is of importance so as to exclude that impromptu type of explanation that is very poorly organized and sometimes given in a laboratory class under the name of a recitation. The recitation up to now has been little used in our subject, but its value is now being appreciated. As a consequence, it has a place in conjunction with other forms of exercises in the teaching of Engineering Drawing. This class should be well organized and to overcome its chief weakness, it should be remembered that mental activity is essential to the learning process so that the instructor should exercise great care in seeing to it that all the mental activity is not confined to himself and one or more of the bright students as activity of the few does not necessarily promote and guarantee class activity.

The problem method attempts in some measure to introduce into the school the same situations which ordinarily arouse thinking or general mental activity in normal daily life.* This type of learning exercise is concerned with more than subject matter and a skill of the drill level as it cannot be solved by instinctive or reflex actions or by remembered solutions. It has as its basis a situation of such a nature that reflective thought is necessary for its solution. This form of mental activity is of the highest order and requires the collection of data, together with its elimination and organization, as well as generally offering a choice of more than one possible solution and always requiring a method of reasoning for the obtainance of a solution

The above point of view is more or less what we may call the traditional one and is the one generally associated with the word problem. We cannot cling to this concept in our discussion because while a good many of the so-called problems given in an engineering drawing course are problems in the above sense a great many more are not so and would be more accurately classified under examples illustrating or furnishing drill for a definite set method of solution.

* As defined by Professor R. P. Hoelscher in the Teaching of Mechanical Drawing---------------p. 41.

Our point of view, while not consistent with theory, is in harmony with that practice used in the texts books and in the standard nomenclature used in the literature of the subject.

In treating with the teaching of the problem the factors of analysis, method, and solution are of interest from the psychological point of view, while the source and the use of the problem are of interest in organizing the course of study. From a study recently made by Professor C. L. Svensen of Texas Technological college, he found the following were the common sources for problems used in the teaching of engineering drawing:

Text books
Problems originated or developed by the instructor
Reference books and problem books
Blue prints from industry
Illustrative problems from textbooks
Illustrations from engineering catalogues
Adaptations from machine parts and actual
machine parts
Projects of various kinds

Of all the sources given the textbook is the most popular for the elementary course as they have been prepared for that definite purpose, are correlated with the text, and are generally laid out, thereby saving the instructor's time.

While the source of the problem has a direct bearing on the make up and layout of the content of the course of study, what is of greater importance is the use to which it is put. With respect to the use we need not think that if the problem method of teaching is selected that all our decisions are made because the problem may be used in conjunction with any

of the other major techniques of teaching. The teaching of the problem requires that we look beyond the subject matter and teach in addition to this the problematic attitude which to the successful engineering is indispensible.

Under the pure laboratory method the students work out problems one after the other and are given what help they need by means of mimeographed directions, text books and individual instruction. The time is used for supervised study, instruction and solution. It is interesting to note that physics, chemistry and biology started by being taught on a purely lecture and recitation basis, but under the impulse of the late Charles Elliot adopted the laboratory plan as one part of their teaching method. The subject of drawing which was formally taught wholly as a technique or skill subject was originally taught entirely on a laboratory basis. That this subject is now emphasizing the acquisition of knowledge, attitude and appreciation as well as skill is the real cause behind the adoption of the lecture and recitation methods as a part of its teaching program. That the old tendency still persists and that the new is being introduced in a variety of forms is well illustrated by a survey recently made by Professor C. V. Mann of the Missouri School of Mines. This study was concerned with the work of teaching drawing and descriptive geometry in one hundred leading engineering schools. Seventy four schools replied to the question regarding engineering drawing and the following

facts were obtained:

- 49% of schools teach drawing by the laboratory method only
- 51% give weekly lectures in addition to the laboratory work, the total lecture time varying from one-half to one-third hours per week
- 30% accompany the lectures with home study
- 16% list definite recitations with laboratory work
- 13% have recitations, home study and laboratory work
- 11% have lectures, recitations, home study and laboratory work.

The preceding facts indicate that at the present time one-half of the colleges are using the laboratory plan of instruction only, while the other half use the laboratory method in conjunction with other methods to complete the teaching work. Whether the laboratory method is used by itself alone or with other methods it is not a definitely fixed procedure applied alike in all schools by all instructors, but in practice consists of the pure laboratory system as previously described, the pure test system, and the modified laboratory system.

In the pure test system each class is conducted as a test with the students working on problems assigned at the beginning of the class. These problems are to be handed in at the end of the class whether completed or not. Practically no personal assistance is given the students but in the majority of cases they are allowed to use texts and notes. This really amounts to supervised study the principle being

that all learning is self-learning together with John Dewey's philosophy of learning by doing. This system is generally used in conjunction with either the lecture or recitation methods so that the theory explained in one is applied by the student in the other.

In the modified system the class is much more informal than that of the test plan. The instructor circulates around the class answering students' questions by leading questions, references to the text, or by sketches and explanations of the theory or principle involved. The objective is to assist students in acquiring the ability to analyze the problem, choose a method of solution, and solve the problem by the application of accepted methods with a speed and skill consistent with accuracy and neatness. In the larger colleges the tendency has been to have the classes larger than the accepted size of from twenty to twenty-five men and to have two instructors one circulating in a definite order and the other assisting those who from time to time need special help.

In concluding our comments on the laboratory system of instruction it should be stated that it is flexible enough to meet the particular situation that may present itself, that it may be the sole method of instruction or used as a part of a general teaching program, that it offers a great opportunity to cater to individual differences and that lastly it is not as commonly thought a class in mechanical drawing for developing drawing skill alone but it is rather in the nature of a supervised study and at the same time offers

[illegible]

[illegible]

[illegible]

individual recitation.

Stormzand in his "Progressive Methods of Teaching" has defined the lecture as a topical recitation by the teacher, with the purpose of classifying, interpreting or supplementing the pupil's learning from other sources. Ira O. Baker of the University of Illinois uses the term lecture system to designate that method of instruction in which knowledge is presented by the instructor without immediate questioning or discussion by the student.* Both of these definitions are concerned with the formal lecture where subject matter is all important and those things are told by the instructor which the students cannot find the answers to without too much loss of time.

The lecture as refered to views the material imparted as the end of the teaching performance and not as a means to a greater end. When looked at, as a means to an end having as its aim the development of attitudes, skills and the acquisition of knowledge we will use it as a part of our teaching program to supply those outcomes, and only those, that can advantageously be imparted by it. In order that it may be effective as a part of our program and blend harmoniously with the other parts it has been found that the formal lecture is inadequate. The new material of our course

* Klapper Paul--"College Teaching"--Chaper XXV--World Book Company, New York, 1920.

is to be acquired in a manner that makes the knowledge, the application and the skill all one outcome, each incomplete without the others. This being the case the demonstration lecture is used as an efficient way of teaching the knowledge of the course, demonstrating its use in a definite problematic situation by the application of the principles taught and the use of drawing techniques.

The status of the demonstration lecture is well stated by Downing in the following quotation: "The lecture demonstration method of instruction yields better results than the laboratory method in imparting essential knowledge and is more economical of time and expense. This is true for both bright and dull pupils and for all types of experiments. The lecture-demonstration method appears to be the better method for imparting skill in laboratory techniques in its initial stages and for developing ability to solve new problems."* This statement is very convincing, but it should not be assumed that this form of lecture is the same as a formal lecture plus a demonstration. To be correct this learning exercise should be informal having the instructor work out the demonstration problem with the students inviting suggestions from them by means of stimulating questions.

* Downing, Elliot, R., "A Comparison of the Lecture Demonstration and Laboratory Methods of Instruction in Science."---------School Review--pp 688-971--November 1925.

The assignment and the following class or laboratory problem have a direct relation to the lectures and demonstration. The lecture-demonstration to have its maximum effect should start with a review of the preceding work as a basis for the teaching of the new principle. In speaking of preceding work we include the assignment just completed which serves as a body of information acquired as knowledge now to be mastered through use and applied to a definite problem. The previous work including the assignment are thereby helped by attaching new significance to them by way of further applications. Having satisfied this condition we have considered only one function of our lecture-demonstration the other being to teach the proper applications of the new principles and skills that are needed for the solution of the class plate to follow. For this to be possible the class problem must first be analyzed with respect to the abilities necessary for its completion. Having determined all the information, processes and skills necessary to do the class plate the instructor should design a new problem for demonstration purposes that will illustrate the uses of the same abilities to be used in the class problem. These problems should be different enough so that the student will have to understand the principles and practices involved in order to do the class problem.

Getting back to our justification of our course of study and teacher's manual as an aid for improving teaching techniques we can readily see that for the proper development

and application of the lecture demonstration it has many advantages. The most important are the setting of a definite content, the analysis of the problems contained in the content, the selection of the demonstration problem on the basis of the analysis, and the make up of the assignments to fit in with the demonstration. All these factors that enter into the teaching situation as related to the lecture-demonstration method are properly taken care of in the teaching of Engineering Drawing by the aid of the course of study and teacher's manual.

The last major technique that was included in our list is the project which was originally defined by Stimson of Massachusetts Agricultural College in 1908 as a sizable operation carried out as an adult would carry it out in real life. This teaching procedure is not a class room activity and was originally confined to the teaching of the industrial arts and agriculture. The following is the writer's definition, and will be used for the basis of our discussion. "A project is a sizable real life undertaking planned and executated under supervision and organized about activities outside of the class room. The project should have economic value as well as growing out of the direct and immediate needs and interests of the students."

From the above definition it is easily seen that the instruction given under this method would be highly individualized and that the selection of the particular project would call into play the students interests above those of the

instructor. It would be difficult therefore to sanction a project unless it required the application of those mental and skill abilities that the objectives of our course call for. This method of instruction has been given considerable worthwhile study and it is at present used in some forms of secondary education being justified on the basis of the high degree of pupil purpose and self-motivation present as well as applying the knowledge and skills as they are acquired or rather acquired because of their use.

Although the term project has not many years behind it in the field of secondary education there has been in use in the last thirty years a method of teaching, having no definite name, but identical in method and purpose with the project, and used in teaching the design courses in the advanced applied courses in our engineering schools. The teaching of law by the case method of instruction is another example of a method common in spirit but not in name with the project.

A further consideration of this method of instruction would be of little avail for our purposes as the project in my opinion haslittle place in a course of fundamental principles, such as our course is to be. This statement is true for the following reasons:

That it should be confined to classes who have had some experience in the subject and used more for application than acquiring new principles.

That in the limited time available it would be practically impossible to find suitable projects that would involve all the

principles that should be included.

That the highly individualized method of instruction adapted for the project would be inefficient in a class meeting only two hours a week and having approximately twenty-five men in a class.

That it would be as logical to start the study of engineering drawing with a project as it would to write a thesis for a graduate degree in education before entering upon a program rather than using the thesis as a project to show how the subject matter and attitudes acquired by graduate study may be definitely applied to some educational problem.

We have considered the major techniques as more or less separate entities because of the conventional divisions of terms that all adhere to for ease of classification and explanation; And not because each one is distinct and without relation to the other. The attitude we want to leave is that in specifying the major techniques for our teacher's manual we should not have a mental set for any one technique to the extent of rejecting any useful practice. It would be better if we used any number of proven practices that will yield the desired results even though the consolidation of all the practices is such as to surmerge the name of any one of them to the extent of not having one term characteristic of the whole and included in any one standard teaching major technique.

The minor techniques are an outgrowth of the major ones serving to adapt them, or it, to the particular class organization at hand; such as, the size, the frequency, and the length, together with the previous training of students, degree of pupil purpose, and the caring for individual cases within the class. These minor techniques are all worthy of some explanation. The technique of measurement is of such importance as to warrent a complete chapter in a later part of this thesis so that we will leave its treatment until that time. As in our previous discussion the order of explanation will be identical to that as listed in the original statement which was, for sake of recall, the question, drill, review, appreciation, assignments, and last, which we are not concerned with for the present, measurement.

The question and answer method of teaching is probably the oldest method and for the growing child the most efficient. That this form of imparting knowledge is not confined to the pre-adolescent alone, but has commanded the attention of one of the greatest of minds is well illustrated by the work of Plato in his "Republic." The writer has found that in the writings on the subject of questioning the assumption has always been made that the situation requiring the use of the question is the typical old type of class recitation where the instructor asks all the questions leaving all the answering for the students.

In considering the few thoughts we are to state it should be remembered that the above situation will not be the

case. This is due to the fact that part of our teaching work will be on the laboratory basis where the students ask most of the questions. When the student asks the question it is very apt to be of the fact type requiring a definite reply. In the majority of cases the student can answer his own question if he is made to frame his question and define the terms that he uses. The very fact that he asks the question is due to his confusion with respect to what the particular facts or methods mean. If the instructor insists on a clear statement of the question each time the students will soon do considerable thinking and fact finding in framing his questions, thereby, automatically answering many of them. This matter of guiding a boy in securing, without his being too, conscious of it, his own answers is giving him training in methods of study that are very basic and general enough to allow a transfer to the other subjects on the curriculum. Many times the question of a student may be answered by having the instructor reverse the procedure by asking the student questions which answered correctly lead him toward the proper solution of his own original question. Care should be exercised by the instructor not to turn on the student quickly with the return questions giving him the impression of being abrupt and sarcastic, thereby discouraging the student from asking future legitimate questions.

The two types of questions just referred to were the

fact question and the development. The fact questions call for a specific response by the instructor, such as a student asking what size to make the margin lines of the paper, the proper height for lettering, where to locate the auxiliary view, what is the size and location for a hole in a side view which is already defined in the top and front views. The questions which are fact questions from the student's point of view may or may not be answered by a factual response by the instructor leaving the option up to the teacher.

Using as an illustration the question calling for the size and location of a hole already defined in the top and front views it is seen that the instructor may choose the easiest way out and teach the student little or take a little effort and lead the student toward the correct solution of his own difficulty. If he employed the easiest way he would make a statement some what as follows: The size of the round hole is $\frac{3}{4}$" in diameter and its center line is 3" from the front edge of the object and it extends from the top surface to a depth of $1\frac{1}{2}$". The student upon receiving the factual type of reply would give a characteristic nod, denoting complete understanding on his part, proceed to represent the hole correctly in the side view and be at a loss again when a similiar difficulty presented itself. If in place of answering the fact question by giving a factual reply of little instructive value, the instructor had employed developmental questions leading the student to find his own way out of the difficulty, there would have

been some real teaching. The following type of developmental questions would have led the student to the proper solution:

Q. The width of the side view is the same as the width of what other view?

A. The same as the width of the top view.

Q. How far is the center line of the hole in the top view from the front edge?

A. 3"

Q. How far is the center line of the hole in the side view from the front edge?

A. 3"

Q. What is the true size and shape of the hole, and what view shows it?

A. Circle $\frac{3}{4}$" in diameter. The top view.

Q. What will be its width in the side view and how are invisible edges represented.

A. $\frac{3}{4}$" in width and represented by dotted lines.

Q. The height of the side view is the same as the height of what other view.

A. The front view

Q. Now, how deep is the hole from the top surface in the side view.

A. The same as the front view which is $1\frac{1}{4}$" deep.

The above type of development questions require some patience on the instructors part, but each time should be clearly stated, indicative of what is wanted and time should be given for a full and complete answer. This form of questioning is practically always limited to the instructor although occasionally the brighter students will quiz the teacher with leading questions that lead definitely toward

the solution of hiw own problem.

The above point of view is more or less restricted to laboratory and individual teaching. This does not complete the topic of questioning as there is another form known as the thought question which is of considerable importance. Again, like the development question, it is generally restricted to the instructor. This form of question is very hard to frame and requires a complete understanding of the material involved for a satisfactory answer. It does not bring forth a remembered answer and often involves comparisons, relationships, and choice, together with their supporting reasons.

The success of this form of question is governed to a large degree upon the instructor's ability to frame the question and then to evaluate and make proper use of the answer. It would be very difficult for an outside observer to determine from the question above whether or not it be a fact or a thought one. This distinction is based upon the educational back-ground of the student. What may be a thought question today may next week upon the mastery of present-day material become a fact question.

To illustrate, let us assume that it is the first or second lesson of the course and the instructor asks a student what the bow dividers are used for. This immediately envokes a response whereby the student first calls to mind what they look like, then comparesthem with the other

instruments, eliminates the various instruments as to use, probably taking the obvious ones, such as the ruling pens first and next by comparison and analysis of function arrives at the use of the bow dividers. This same question, if asked later on in the course would be a drill one requiring a definite statement, fixing the association between the bow divider and its use.

The last functions of the question which we have not, as yet considered are of great use in connection with lecture and demonstration work, and consist of their use as a means of stimulating thought and unifying knowledge and procedure. In starting a demonstration lecture it is often useful to ask some questions related to the work to be taken up, the answers to which are of interest but not known. The work of the lecture then resolves itself to the unfolding of the material in such a manner as to leave the question fully answered. This keeps the student interested and keeps the instructor from wandering off and not meeting the definite objective of the lesson. The use of the question for unifying the material of a demonstration is of value in having the students see the application of the new principle and practice in addition to the relation of the new work to the material preceding it.

A drill unit is that subject or part of a subject containing enough elements, whether ideas, facts, or skills to be learned in a definite form or mastered as a skill. It should be of interest to the student and capable of being taught by that habit-forming process known as the technique

of drill. This learning device, although of importance in the first part of a course in Descriptive Geometry, is of little importance as a class exercise in our course in Engineering Drawing. This is true because the natural arrangement of the work is of such a progressive nature that the acquisition of the drawing skill necessary is gradually acquired without the aid of any specially designed drill exercises. Those parts of the work which reduce themselves to the drill level are the use of instruments, line work technique, copying layouts, use of scale, and lettering.

The general application to a complete class of this technique is of minor importance, but it is the writer's experience that in pratically every class in drawing there has been one or two studentswho possess the mental ability to acquire an understanding of the subject, but have such poor hand and finger dexterity that to make a credible looking drawing requires a great deal of slow painstaking anxious effort. These men never seem to be able to reduce the drawing skill down to an automatic or drill level. They should not be discouraged from taking the work because many of them show by means of objective tests that they have acquired a real understanding of the subject. These men will never make good draftsmen but are capable of becoming first-class engineers.

The best solution that the writer has found for this problem is to first determine whether the student has an understanding of the work and then if he has to allow him

extra time to improve the line work on his drawing plate outside of class setting his maximum grade below that of the other students. When it is explained to the student that speed and skill are elements that enter into the ability to be measured and that lack of it should reduce his grade he sees the fairness of the plan and is more than willing to co-operate in an effort to improve his work. This plan has worked out well and has the advantage of keeping up the standard of line work and neatness of papers presented.

When we consider that real review gives added significance to the old subject matter our course is ideal in that it automatically does this very thing. Let us assume a course starting with geometric constructions for the purpose of developing drawing skill and for imparting knowledge. This would be followed by an orthographic projection problem involving geometric constructions as well as the new orthographic principle. The next topic of auxiliary views would give new significance to, and review both the geometric constructions and the orthographic. From this point the course would precede to the intersection of solids which would again automatically cover all previous work. We could go through a whole course of study and find a natural progression further illustrating this condition.

Having in a few words set forth our position with respect to the major work of review it would be well to consider some of the other purposes of the review exercise as

set forth by H. R. Douglas in his "Modern Methods in High School Teaching." In addition to giving added significance to old work it should give the students a view of the subject from a distance where by they can secure an idea of the organization, emphasis, and relation of the subject matter, together with a measure of the relative importance of the various parts. The other purposes given are to reveal the weaknesses of the class or individuals, as a basis for remedial teaching and to lay a basis for the approach to new subject matter.

The first purpose is well taken care of by the course outline that is put into the student's hands.. Due to the shortness of the course it can contain only essentials with the relative importance varying directly with the time distribution. For a general review of the semester or of the year, the student has his outline of lessons together with his completed drawings. The work of detecting individual and class weaknesses is well provided for by means of the laboratory period where the instructor keeps in intermate touch with the progress of each student offering suggestions that best fit his case and if a weakness is found to be of a class nature he adjusts the class routine to remedy it. Review as a basis of approach to new subject matter is of importance in organizing the lecture demonstrator. This function is taken care of by accumulating and recalling old material in the form of a summary that reviews the work to establist a basis for the teaching of the new principles and practices

that are taught as being a logical outgrowth of the previous work.

All subjects have some degree of appreciative and cultural value, some, such as literature and music appeal primarily to the emotions and are taught wholly on an appreciative basis. Although commonly conceived of as being cultural in their nature these same subjects may be classified under the vocational class when studied with the purpose of applying the knowledge as a means of earning a livelihood as by teaching or writing. The distinction employed is one of attitude only. In the first case they would be studied for the pleasure one derived from working on, observing, or thinking about them, while in the second case the studentis concerned with the vocational or economical efficiency he is developing. This does not mean that under one condition there is involved only enjoyment, admiration, sympathy and interpretation while under the other only the professional side is stressed. The difference is on the basis of the objective of the training one having its direct outcome appreciation, the other having professional efficiency as the direct outcome with many other indirect outcomes, appreciation being one of them. In keeping with this reasoning we may say that for the professional lawyer music would be an appreciation subject while for the professional musician the study of music would be vocational and the study of law, if for recreational purposes, would be cultural.

With the preceding thoughts in mind we may now state that for those who do not become draftsmen or engineers our course will have permanent effects that are chiefly cultural. This becomes a transfer of attitude and does not affect the practice of teaching the subject matter at this time as being of a professional nature. Neither does it say that none of our work can be reduced to an appreciative basis. An intimate knowledge of the labor and difficulities involved developes a sense of appreciation for the work of others which has real meaning. I say real because real appreciation comes with mastery and to try to instill a deep feeling on a complete entity when it is only partly known is rather a superficial culture. To this end the instructor should at all times try to convey his appreciation of the subject by showing a complete mastery, admiring the results of the science and interpreting the results in terms, interesting and pleasant, for the students to reflect upon. Although this procedure should be a characteristic applied to the teaching of all elements in the course there are particular items, such as, lettering, freehand sketching, and perspective projection which lend themselves particularly well to appreciative attitudes. These should be given special attention in order that the cultural as well as the vocational side be acquired by the students.

The engendering of the appreciative attitude results in the creation of new sources of interest in the students.

Care should be taken to properly motivate and adjust this interest to meet the needs and level of the class. To illustrate this point we will assume that our next lesson is on perspective projection. As preparation for this the student should be asked to observe that in looking down the avenue the lines of the building tops, the car tracks, and the telegraph poles all disappear at a common point. This is true for that condition, but when viewing a large building at an angle the lines of the windows on one side converge at a point while the lines on the other side come together at a different point. These and other questions that appeal directly to the experiences of the class serve as a good introduction by creating a genuine interest resulting in their want for information upon the subject for reasons that are not entirely vocational. Following an impressive introduction by an interesting presentation the students will master the material to such a degree that in addition to making a perspective drawing they will be able to determine upon inspecting a picture just where the observer stood, why he stood there and many other interesting points that are a source of enjoyment whether looking over the illustrations in a magazine or observing the paintings in the art gallery.

The results of the correspondence schools are objective proofs of the great work that can be accomplished by means of properly designed assignments. They have demonstrated

how an ambitious student, many times not knowing how to study, can, under the guidance of a well-planned list of assignments, go a long way. The seriousness of the student may be taken for granted, but the assumption that all boys who graduate from high school know how to study does not check with experience. The responsibility of the instructor to supervise the studying of the students while in class is universally recognized but that the assignment, which is an intergral part of the teaching performance, should be guided to the same degree is more of a philosophy than a practice. These general study helps, which would not be in writing are important because of the large amount of equipment required and the physical effort that must be expended that is not common to other studies. Such helps as having a definite and well-adapted time and place for studying including good light and air, proper height of chair and table, free from any distracting elements and environmental factors should be stressed at the beginning and during the course. The mental factors such as starting to work at once, knowing just what is to be done, and spending as much time reflecting on the results and methods as in doing them are considerations the boy should be led into using.

The exact requirements of each assignment must be defined by the instructor before the close of class. Just what is to be read, what to be studied, what problems to be

solved, and the degree of mastery expected should be told the students before they are put on their own. In doing this and giving certain problem layouts more rapid progress may be made, time saved, and a marked increase in the amount of work that can be covered is made possible.

There are two commonly used methods of making assignments, one calling for the study of advanced matter only, while the other uses it as a means of drill for old material without relation to any new principles. Between the two there is a ground that we will employ. In this way drill work will be provided by completing drawing plates at home and the advanced preparation will consist of text assignments to form a basis for the lecture-demonstration of the next class. By doing this we will co-ordinate the text assignments, lecture-demonstrations, drawing room problems, and home problems into one harmonious teaching procedure as specified by the course of study and teacher's manual. This scheduling of the complete course of study makes it possible to place a list of assignments before the students in printed form. The responsibility for the year's work will then rest squarely on the student' avoiding that confusion that so often occurs where he is absent or in any other way irregular.

D Aid for the Supervision of Instruction.

"Supervision is concerned with what should be taught, when it should be taught, to whom, by whom, and to what purpose."*

*Elliot E. C., City School Supervision--World Book Company----1914--p. 12.

We will use this statement as a guide for our justification of the course of study and teacher's manual as an aid in the supervision of instruction. Breaking up the definition and stating the same thought differently, we find that supervision is concerned with content, curriculum, student, teacher and objective. Although treating with the factors enumerated, it has as its purpose the improvement of teaching.

In the organization of an evening school it is the work of the founders and later executives to first decide just what type of educational service it can render to the community that is needed and not provided for by any other educational or outside agency. It is this decision that definitely sets the type of student body. Assuming this factor to be already decided it is our task to adjust the other factors in the teaching situation that will aid supervising Engineering Drawing as a subject in the curriculum having the correct content consistant with the objective and properly taught by the instructor to the type of student that the school is designed to assist.

Our course being designed for an evening school implies those differences in school organization and administration that place more reliance upon the proper selection of teacher and upon the course of study. Probably most important among the many factors that effect the teaching performance is the lack of a real live departmental organization. If one were possible the teaching efficiency would be greatly enhanced.

This would mean there would be departmental meetings with the staff members jointly agreeing upon the teaching objectives, course content, methods of teaching, selection of materials, plan of course, techniques for measurement, and design of problems. In this case each instructor would have assigned to him the work of studying and reporting on one, two or several of these factors to be later discussed and accepted by the entire department before their final adoption. The outcome of these meetings would be an agreement as to just what constitutes good teaching. This is an all-important consideration as only those instruments for judging are worthwhile that are understood and agreed upon by all the teachers. The judging of teaching being considered as an aid for improvement and not as a means of rating the teachers according to any standard rating scales.

When speaking of departmental organization in an evening school of our type and size, we have been speaking of what would be an ideal arrangement, but what experience has shown us does not exist. The functions that we have stated should be carried out by a departmental organization must now be assumed by some other agency if our teaching is to be of the highest type. It is the assuming of these responsibilities that justifies the course of study and the teacher's manual.

Going back to a picture of good teaching we find it consists of the correct sort of subject matter and activities being taught in the correct manner in a setting that is more

favorable for the type of work to be done. The course of study has assumed the complete burden with respect to the content of course while the teacher's manual has taken over the work of asjusting the methods to the course contents and students. The setting or general atmosphere will take care of itself if the other factors are well worked out providing that the selection of the teacher is of the best. In selecting the instructor the administration has of its own free will consciously set the standards for the personal factors they want to be present in the teaching situation while the professional standards are those we are endeavoring to raise. With respect to the teaching personal our set up permits the meeting of an emergency situation without seriously disturbing the teaching program. If for any reason an instructor cannot meet his class a substitution can be effectively make. By definitely showing the substitute what is to be taught and how it is to be done the course of study and teacher's manual assumes another function of the ideal situation normally assumed by a departmental organization.

CHAPTER IV

The Course of Study

Our first interest was in a formulation of the objectives of our course in Engineering Drawing. The defined objectives gave us a basis on which to build our structure. We next found that in order to build the structure upon the objectives a course of study and a teacher's manual would be of value as a means of fulfilling the objectives, providing a proper perspective, as an aid for improving teaching, and a help in the supervision of instruction. The second chapter which we may call one of justification will serve as a background for this later work which is concerned very definitely with the course of study. In this chapter we will look into what content of course means and just what it should contain for our particular case. Upon the completion of the course content the material will be weighed, and organized, the text book and problems selected, the course outlined, the plates layed out and the assignments listed. In doing this we will be in a position to proceed with the teacher's manual to accompany the course of study.

A Content of Course

We know the educational background of the students and we know the objectives of the course. This necessitates that we manufacture some form of vehicle to transport the student from where he is to where we want him to be. This vehicle is what we term ~~as~~ content and is selected for the purpose of

providing a body of material to be manipulated by teaching practices as a means of attaining the goal of the course. As in the teaching of every other subject we shall have to eliminate many interesting topics because of these limitations. In order that we be objective in selection the following criteria will be considered in making our final selection:

1. The course of objective
2. Contents of outstanding text books
3. The contents of other subjects in the curriculum
4. The principle of relative value.

The principle of social values which measures the content as it affects such social factors as health, culture, vocational training and social civic pride has together with student capacity been purposely excluded from the list because its function is taken care of by the course objective. The course being of an elementary nature also excludes the availability of material as a factor in determining the content as it does in more advanced work where the necessary material is not always published and easily accessible.

The objective we accepted in our first chapter stated that the engineering drawing course should contain both cultural and utilitarian values. From our discussion on appreciation we may conclude, that such consideration as development of an appreciation of another man's work and a mastery of material are cultural factors that we can expect to engender. In addition to this the subject of perspective

projection will be given a place in the contents on the basis of its direct cultural value. That our course will be restricted to fundamentals and have a high degree of utility in engineering will eliminate all abstract material that is contained in many longer courses.

Upon examination of three of the most widely used text books on Engineering Drawing the writer has found that they all contain what may be termed fundamentals, plus some special knowledge, hobby or special material fitting a particular need that the author wrote the book to fit.* These specialties we are not interested in but the fundamentals were practically in agreement in all texts with the exception of Svensen's, "Drafting for Engineers," which in its present edition does not include perspective projection although a new edition which will be printed within the next year is to include that topic.

There are three sides of evaluating material on the basis of the contents of other subjects in the curriculum. The first is what principles do the others teach? The second is what material must I include to provide the proper prerequisite for advanced study? The third being what can I put forth that will fit in with the other subjects the students are now studying? What the other courses treat is of interest

*The text books referred to are: French T. E. "Engineering Drawing," McGraw Hill Co. New York 4th Ed. 1929--Jordan H. H. and Hoelscher R. P. "Engineering Drawing" John Wiley & Sons, New York 2nd Ed. 1928--Svensen C. L. "Drafting for Engineers" D. Van Nostrand Co. New York 1927.

in ruling out all things that are included in other courses of study. In our particular case this consideration would affect only the particular geometric construction problems that we select and our method of approaching them.

As a prerequisite for further study in machine drawing, architectural drawing, civil engineering and machine design, a complete study analysis of the advanced course should be made before prescribing the minimum essentials of our contents. Such a study would be a thesis in itself and is, therefore, beyond the scope of this undertaking. It seems very probable that the outstanding text books have considered this factor in the selection of their fundamental principles so that we may be getting the indirect benefit of some such study. One very striking exception to this principle of laying the proper foundation is that practically all the elementary courses teach either the straight or inclined single stroke Gothic lettering, while professional civil engineering requires Modern Roman and the architects use the Old Roman form. There are justifications for this practice but it is questionable if the limitations of the adaptability of similar form of lettering was considered in its original selection.

In attempting to adjust our work with the subjects of mathematics and physics which are being taught simultaneously we can introduce to advantage free-hand sketching as an aid for improving the diagram work in physics and trigonometry and the conic sections and curves from a new point of view as a help in giving new significance to the work in analytical

geometry and elementary calculus. For this to be effective it must be introduced into the program at a time to co-ordinate it properly with the other subjects.

We have previously stated that content affords us a means of going some where. Now we may leave one point and arrive at another predetermined point by an infinite number of ways providing we do not place a time limit on our travel. Just as soon as our mode of travel becomes restricted by the factor of time, it means that we may either travel over a long path at a fast rate, or go over a shorter distance with a slower velocity. Believing that, in the long run, the latter alternative is the most economical one it becomes necessary to cut our content down to an amount that can be well taught in our allotted time of thirty lessons. In as much as we cannot include all topics we shall include only those that are of the greatest relative value in terms of the course objective, text books, other subjects on the curriculum, and the specified time of thirty lessons. In boiling the material down we find that the following topics are fundamental but cannot be taken up by us in this introducting course; the helix and applications, nuts and bolts, simple details and assembly drawings and tracing.

On the basis of the criteria set forth the following list of specific content is given as representing that body of subject matter we will design our course of study to teach. The list at this time has not been selected with any particular text book in mind, nor is it arranged in any particular order.

The weighing and organization of this material for purposes of increasing the teaching efficiency will be the next task to engage our attention.

Specific Content

1. Technique practice
2. Geometric constructions
3. Lettering
4. Orthographic projection
5. Auxiliary views
6. Conic Sections and curves
7. Revolution
8. Sectioning
9. Intersection of prisms with prisms and cylinders with cylinders.
10. Development of surfaces.
11. Isometric drawing
12. Perspective projection
13. Free hand sketching
14. Dimensioning

B <u>Weighing and Organization of Material</u>

Under the previous heading we acquainted ourselves with those factors warranting consideration in the selection of our course content. On the basis of these factors we then specified very definitely just what our particular content is to be. In order that we may arrange this unorganized list to allow for its adaptation to a thirty lesson course we must first decide upon the proper arrangement of the topics to insure the progressive application of principles and secondly the time to be allotted to the study of each topic.

In listing the topics in an order that allows for good teaching we many times have to disregard what may, to the outsider, seem very logical for an order that is psychologically, if not logically sound. The psychological order is based on experience in teaching coupled with a knowledge of the laws

of learning. One may say on this basis that there would be as many different arrangements as there are teachers as no two have had identical teaching experiences. As this is undoubtedly true we will accept an arrangement that can be defended from the point of view of the laws of learning and actual teaching experiences providing, of course, that sound teaching practices are used for justification. The problem of evaluating the contents for purposes of deciding on the time distribution is not based upon experiences as much as it is upon the objective of the course. Having these thoughts in mind the writer offers the following course outline as one capable of standing the test of experience in teaching, the laws of learning, and consistancy with the course objective.

1. Introductory Lecture
2. Technique practice
3. Geometric constructions
4. Lettering
5. Orthographic projection
6. Free hand sketching in orthographic projection
7. Spacing of letters and title design
8. Orthographic projection and dimensioning
9. Orthographic projection
10. Two hour examination
11. Orthographic projection (obtain third projection from two given ones)
12. Revolution
13. Auxiliary views
14. Auxiliary view
15. Mid-year Examination
16. Conic Sections
17. Conic Curves

18. Sections
19. Sections
20. Intersection
21. Intersections
22. Intersector (cylinders)
23. Two hour examination
24. Development
25. Isometric Drawing
26. Isometric Drawing
27. Oblique and cabinet projection
28. Perspective projection
29. Final Examination

The validity of the above outline rests in the justification of it, so it is appropriate at this time to consider the following items as factors causing the arrangement to be as it is.

Technique practice is started in the second lesson as a means of satisfying the student's desire to use the instruments. This fully orients him into the drawing work and further motivates him by raising him to the plane of a draftsman using his instruments and producing a finished plate. Geometric construction problems follow the technique practice and offer an opportunity for developing more skill in the use of instruments, gives graphical significance to much of the geometrical knowledge they already possess, teach the problematic attitude, and call for exactness in the solution of the problems.

The deferring of lettering to the fourth lesson was consciously done as an attempt to break down the unfavorable mental set that the students coming from high school have regarding the subject. An opportunity is afforded the instructor, in the first three lessons, to gain the confidence of the student by giving him a reason for everything he is

asked to learn. With this rational point of view developed the instructor is now in a position to teach, and the student to learn, the correct lettering forms from a thoughtful analysis of the alphabet and not by excepting some standards on faith alone. Off hand it would appear logical to follow this up with the spacing of letters and title design. If this were done the class would get impatient and immediately lose interest as they would have been attending class over a month without making what they term a real drawing. To prevent this tiresome repetition of what may be termed a skill topic, the work is split up by sandwitching the first lessons on orthographic projection between them.

The work of free-hand sketching is introduced by applying it to the second lesson on orthographic projection for three important reasons. The first being that it is well to follow up the training in finger and hand dexterity, offered in the lettering exercise, by further applying it to making longer lines and developing a sense of proportion. Another reason for inserting it at this time was to help train the students so that they can make good free-hand diagrams in the subjects of physics and mathematics. The last one is that it offers a method of very economically teaching the principles of orthographic projection. The boys at this point have not developed sufficient mechanical skill and speed to even copy work without considerable effort. Because of this, when they are given a three view drawing to make mechanically most of

their time is spent in laying out the problem with very little attention on the new principle. By means of free-hand sketching the maximum training in the principles of projection can be obtained for the given time. The subject is not started by free-hand methods because it is very important to stress the fact that the relationships between the views must be exact. This is best taught mechanically but when the point is once made it may be economically drilled by the use of free-hand drawing.

The time factor was the deciding element in linking dimensioning up with the projection study. By doing this we are able to secure further practice in projection in addition to learning some of the conventions of the graphical language.

The orthographic lesson preceding the topic of revolution contains a new principle. The problem is to determine a missing view from two given ones. This is taught by means of a reference plan, a method to be further applied in the revolution, auxiliary view and intersection studies. Revolution and auxiliary views go logically together, one illustrating the revolving of an object with respect to a plan while the other considers the object stationary with a plan revolved. The study of conic sections contains another application of auxiliary views as applied to the cone. A complete treatment of the cone would require a course in itself but the instructor can bring out many interesting phases suggesting others for the interested students. His brief explaination will be well adapted for the next lesson on conic curves. Although having practical

value in drawing they also correlate with the work in elementary calculus by giving graphical methods and significance to curves that are studied from the analytical point of view.

Following the curves comes sectioning which is very important as applying the projection work, acquainting the student with new conventions and providing a prerequisite for the later work in intersection of solids. Intersection and development are one; the intersection part being concerned with shape alone while development involves both shape and size.

The last unit is psychologically thought of, and taught to advantage, as one group although the projection principles involved do not logically support such a division. Isometric drawing with oblique, cabinet and perspective projection, are commonly termed the pictoricals. Their similarity is chiefly one of result and not of method. Considering for a moment the theory of projection we call to mind that isometric drawing is an accepted convention for isometric projection to an enlarged scale made necessary by the fore shortening of the sides when revolving the object into the isometric position oblique to all the principle plans of projection. To be consistant with theory this should be classified under a conventionalized form of projection as is much of the section work. The oblique position is very different having one and sometimes more surfaces parallel to a principle plane of projection making it possible to measure true distances on these surfaces. Perspective projection is really nothing more in principle than the point of piercing of lines in a plane. The lines being rays of light

determined by the observer's eye and the edges of the object and the plane known as the picture plane specified for each problem. A decision based on a comparison of the problem analysis of these three distinctive types of drawing and projections would result in placing them in three different catagories. The psychological factor outweighs the analysis in this case as their results are so nearly alike that grouping them together produces teaching outcomes far superior to those obtained under a separate grouping plan. The writer has tried both methods and found that experience backs up this decision.

The reasons just given were in order as a justification for the arrangement of the material specified and defended under the heading of course content. As a guide for setting the time distribution the following assumptions were made; that all the content was worth while, that the entire content was to be mastered, and that the arrangement of the material is fixed. With these conditions fixed we have two methods of approach in proceding. One policy offers very little orthographic projection as such, while the other gives it a prominent place and builds the other work on it. The first practice teaches the fundamental principles as they are applied along with the new material and results in practically an equal time unit being devoted to each topic. Our method allows for a high degree of mastery of the fundamental principles and then concerns itself with the new work. Our argument is that in as much as all the projection work is fundamental it can more

efficiently be acquired as a unit there being enough new applications to confuse the student without consciously planning more for him. This makes for better teaching by directing the efforts toward the acquisition of one new topic each time. This new topic is not taught as an isolated part of the course because the work is of such a progressive nature that the previous learnings are automatically reviewed in each new assignment.

The first examination is given rather late in the course because the beginning involves a large amount of technique practice. If this be examined directly it tends to promote a habit of increasing speed to the sacrifice of neatness and accuracy. The mid-year examination date is defined by the administrative set up. To make this effective, as on other test days, we arranged the topics so that a break came at that time.

C <u>Selection of text-book and problems.</u>

In reading over the prefaceses of many text-books we often find phrases similar to, "this text has been built around a course of lectures given by the auther," and "this book was written to fulfill a need found by the auther in teaching a certain course." These texts are very liable to be course books and not general enough to be used to advantage of many other teachers. They were originally designed to satisfy the requirements of a particular course the auther had in mind. To try and adjust these books to another set of conditions may produce very unsatisfactory results. If the subject is a

common one, and the publishers of the text a large one, the technical editors of the publishing company will, for business reasons, see to it that the text is general enough to permit its use by instructors having varying points of view. The revising of a book is another factor that increases its flexibility. This is done to bring it up to date or to change its organization for purposes of increasing its usefulness to those already using it and to make it acceptable to those who have not been convinced of its worth. These and many other considerations are important in selecting a text-book. In order that we do not spend needless time on features of this topic, which are of no use to us, we will now proceed to list the characteristics we want the book to have to meet our particular requirements.

1. It should cover all the material included in the course content.

2. Its treatment of the subject matter should be suited to the level of our students.

3. It should be general enough to adapt itself to our needs.

4. The mechanics of the book, including clearness of expression, illustration and organization should be of the best.

5. It should contain enough problems to permit sufficient selection and variation.

6. It should have value as a future reference book.

7. It should contain sufficient reference material for present-day use.

All of the qualifications listed must be met by the book of our choice. We want a text by which the student can prepare

for the class lecture and later use it to supplement the teacher's point of view. Up to the last ten years a text in drawing was regarded more as a laboratory manual and problem book. That conception was altered by a change in the objective of the course, and methods of teaching. The objective now emphasizing knowledge, and problem-solving ability as well as skill remodeled the method of teaching to provide an effective means of meeting the new situation. The lecture and recitation were adopted and to meet some of their weaknesses the text-book was made over. The lecture method to accomplish its purpose requires that the student's mind travel at the same rate as the lectures. By means of a well co-ordinated text-book a boy can now go home and dig out the hazy points by tracing the thinking of the auther at a speed consistant with his own rate of learning.

Having the functions of a good text-book in mind the writer very quickly narrowed his selection down to the same three books used in deciding upon the course content. Out of these three the one chosen is an Engineering Drawing by "Thomas E. French" of Ohio State University and published by McGraw-Hill Company Inc., of New York. This book has been revised for the fourth time and has a total issue of three hundred thousand. Before each revision, Professor French, has sent out to the drawing teachers for suggestions and has incorporated the constructive ones into each new work. This book is the outstanding one in the field and meets every requirement that we have stated should be imposed upon it.

A book titled, "Drafting for Engineers," by Carl L. Svensen

of Texas Technological College and published by D. Van Nostrand Company, of New York is a little cheaper and holds second place as the best seller in the field. It was not selected as it has very little value for advanced work, has fewer problems, and omits the treatment of perspective projection. The problems in this text are laid out better, but a little additional work in laying out plates in the course of study can compensate for that. A second revised edition is soon to be published so that any course based on the present edition would have to under go almost immediate revision.

The cost of the books were not considered in the selection. It is felt that the difference of a dollar is a very small percentage of the total cost of an education and all the sacrificing of educational value for such a small amount would not be good economy.

The main source of our problem will be from the text-book. For those branches of the subject which the text does not offer problems meeting our approval, we will either design our own or modify those from other texts. It should be stressed again that when we specify a problem to be completed, we are defining only one element in the teaching situation. The outcomes are conditioned by many factors of which the problem is one. In the selection of the problem we have in mind a two-hour class with an additional two-hour outside requirement. With this time limit before us we then ask, what new principle or practice do we want to teach? What work do we want reviewed? Does it fit in with the material that is to come? How long

does it take to lay it out? How long to solve it? Can the student get far enough along in class to secure the proper guidance for outside work? Can the abilities necessary for its solution be well explained by a lecture demonstration, and does the text offer enough explanation so that if properly studied the problem could be solved? The problem as we have tried to select it with these questions as guides, becomes a well-designed teaching element consistant with the complete teaching program.

D Layout of plates and make-up of assignments.

To layout the plates we need to know the problems to be used and the size of the paper selected. The size of the paper measures 11 x 15 inches with one-half inch border lines reducing the actual working space to 10 x 14 inches. Paper of this size permits the use of small drawing boards and "T" squares making it possible to carry them to and from class. Under these conditions the school is relieved of setting up a routine for handling the equipment and the student has the use of his instruments for doing home work.

The number of problems to be solved on each plate depends upon the time required for solution and the space occupied. A two-hour class period is too short for the completion of many of the plates so that they will be completed as part of the home work. Plates of this type are so designed that the class time is not all spent in laying out the work. The student should get beyond this point and be far enough along in the solution for the instructor to give him guidance enabling him

to complete the work at home. Because of this many of the location dimensions are given for laying out the problems. Those problems not in the book will be drawn up and included in the course outline. All the plates will be numbered. If the course outline makes the statement "start plate number three" it means that it is to be completed at home but if the wording is "solve plate three" then that plate is a class one only and is to be collected at the end of the class. When a class plate is assigned it is followed up by a home plate treating with the same principles. With a set up like this the understanding and speed of a student can be measured by the class plate without depriving the slow man of the opportunity to solve the problems because the following home work contains the same type of material without a time limit specified.

The assignment then, with respect to the drawing work, is either drill or review. In addition to the outside work in drawing there is reading and studying from the text-book assigned. The word, "read" as employed in the outline means a general survey of the material for purposes of getting the auther's point of view. The studying of a body of subject matter involves more than reading. It calls for an understanding of the contents and method of presentation used by the author. The reading and studying done as part of the home work is either used to supplement the instructor's point of view, or to prepare for the next class or for both. The home work functioning in this way offers drill and review for material already covered in addition to preparation for the work to come.

The past, present and future feature of this exercise makes it necessary to build it around and make it an intergal part of the organized content of the course.

To tie all these teaching practices together and to keep their relations fixed we will make up a complete course outline and put it into the hands of the students. This outline will be in two parts. The first part will contain the lesson assignments specifying the topics to be studied, the number of the plate to be solved or started, and the assignment to be made for each lesson. The other division will have the plate assignments that were referred to in the first part. Under each plate number will be the problems to be done and in some cases the arrangement of the work on the paper. If the problem is not from the text a statement or drawing of it will be included in the appropriate place in the outline. The following is the complete course outline that incorporates the contents and teaching practices we have been discussing.

The lesson assignments will be found on the following pages.

Lesson Assignments

Lesson I

Introductory Lecture
Explanation of materials used
Names of Students
Interviews
Home Work:
Read "Engineering Drawing," by T. E. French, Arts 1 and 2 and Study Arts 5 to 15 (inclusive)

Lesson 2

Lecture on use of instruments
Inspection and preparation of material
Preparation of paper with border lines, and guide lines for plate number and name
Start plate 1 (See Plate Assignment of these notes.)
Home Work:
Complete Plate 1, and submit it to instructor upon entering class next time.
Study Arts 42 to 59 (inclusive) and learn all constructions.

Lesson 3

Lecture on Geometric Constructions
Solve Plate 2
Home Work:
Complete Plate 2. Read Arts 21 to 33 (inclusive)

Lesson 4

Lecture on Inclined Gothic Capital Letters and Numerals
Start Plate 3
Home Work:
Complete Plate 3. Study Arts 80 to 88 (inclusive)

Lesson 5

Lecture on Orthographic Projection
Solve Plate 4
Home Work:
Solve Plate 5. Study Arts 229 to 238 (inclusive)

Lesson 6

Lecture on Free-hand Sketching as applied to Orthographic Projection
Solve Plate 6
Home Work:
Solve Plate 7. Study Arts 33 to 35 (inclusive)

Lesson 7

Start Plate 8
Home Work--Complete Plate 8.

Lesson 8

Solve Plate 9
Last half hour of class devoted to a lecture on dimensioning.
Home Work--Study Arts 142 to 155 (inclusive)
Dimension Plate 9.

Lesson 9

Further work on Orthographic Projection and Dimensioning
Solve Plate 10
Home Work--Make a general review of work to date

Lesson 10

Two-hour test
Home Work--Start Plate 11--lay out front and top views and in the upper right-hand corner design a suitable title.

Lesson 11

Lecture on Orthographic Projections (to secure a third projection when two are given)
Complete Plate 11--Start Plate 12
Home Work--Finish Plate 12 and study Art. 93

Lesson 12

Lecture on Revolution
Start Plate 13
Home Work--Complete Plate 13.
Study Arts 89 to 92, (inclusive)

Lesson 13

Lecture on Auxiliary views
Start Plate 14
Home Work--Complete Plate 14.

Lesson 14

Lecture on Auxiliary Views
Solve Plate 15
Home Work--General review for Mid-year Examination.

Lesson 15

Mid-year Examination
Home Work--Study Art 60

Lesson 16

Lecture on Conic Sections
Start Plate 16
Home Work--Complete Plate 16.
Study Arts. 61, 62, 63, 65, 70 and 74.

Lesson 17

Lecture on Conic Curves
Start Plate 17
Home Work--Complete Plate 17.
Study Arts 95 to 101, (inclusive)

Lesson 18

Lecture on Sectioning
Start Plate 18
Home Work--Complete Plate 18

Lesson 19

Start Plate 19
Home Work--Complete Plate 19.
Study Arts 135 to 136.

Lesson 20

Lecture on Intersection of
Prism and development
Start plate 20
Home Work--Complete Plate 20

Lesson 21

Solve Plate 21
Home Work--Study Arts 137 and 138

Lesson 22

Lecture on Intersecting Cylinders
Solve Plate 22
Home Work--Review for a two-hour
examination

Lesson 23

Two-hour examination
Home Work--Study Arts 125 to 130,
(inclusive)

Lesson 24

Lecture on Development
Start Plate 23
Home Work--Complete Plate 23.
Study Arts 104 to 113,
(inclusive)

Lesson 25

Lecture on Isometric Drawing
Solve Plate 24
Home Work--Restudy Arts 104 to
113 (inclusive)

Lesson 26

Lecture on Isometric Drawing
(Curvilinear)
Start Plate 25
Home Work--Complete Plate 25.
Study Arts. 117 to 120,
(inclusive)

Lesson 27

Lecture on Oblique and Cabinet
Projection
Start Plate 26

Home Work--Complete Plate 26.
Study Arts. 245 to 248, (inclusive) and read Arts. 249 to 258 (inclusive)

Lesson 28

Lecture on Perspective Projection
Start Plate 27
Home Work--Complete Plate 27.

Lesson 29

Perspective Projection
Solve Plate 28
Home Work--Review for final examination

Lesson 30

Final Examination.

Plate Assignments

Plate I

Divide 10" x 14" sheet into 6 equal spaces as shown and solve the following problems in the space indicated. Problems 1, 4, 5, 7, 8, and 10 pages 30 to 32 French's Engineering Drawing.

1	4	5
7	8	10

Plate 2

Divide 10" x 14" space into 6 equal spaces as shown. From pages 76 and 77 solve problems 1, 12, 15, 9, 11 and 12.

1	12	15
9	11	7

Plate 3

Lettering ------- The Alphabet
See special problem 1 of these notes.

Plate 4

Divide the 10" x 14" sheet into two equal spaces as shown. Make three view full sized instrumental drawings of the objects in the spaces as indicated. Do not dimension nor letter the objects.

Fig 196 Page 103	Fig 197 Page 103

Plate 5

The directions for this plate are identical as those for Plate 4.

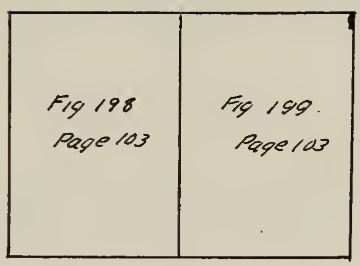


Plate 6

Make three view free-hand drawings of Figs. 1, 7, 5 and 8, on page 91, in the spaces indicated. Choose the scale to fit the space.

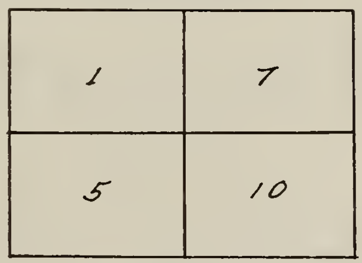


Plate 7

The directions for this plate are identical as those of Plate 6.

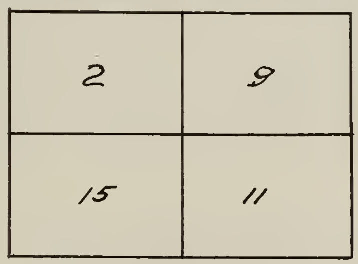


Plate 8

Suppose that you have today completed a drawing, at full size scale, from Main Bronze Bearing for a Jacketed Kettle. In center of the plate design a suitable title for the supposed drawing. Do not make the largest letters more than 5/16" high.

Plate 9

Make a three view full sized drawing of Fig. 207, page 105. The location of problem on the Plate is left to the student. Leave room for dimensions when spacing.

Plate 10

Make a three view full sized dimensioned drawing of Fig. 202, page 104.

Plate 11

Copy full size the front and top views and draw the side view of Fig. 214, Page 108.

Plate 12

Copy the front and top, and draw the side view of Fig 219, page 109.

Plate 13

Revolution of an object.

Divide plate into four equal 5" x 7". Solve one of the following examples in each space. Ex. 1 in upper left, Ex. 2 in upper right, Ex. 3 in lower right, and Ex. 4 in lower left. Represent each edge, visible and invisible, in each view. To prevent serious errors and delays, submit plate to instructor for approval upon completion of Ex. 1, 2, and 3.

Example 1. Draw the front, top and side views of the rectangular prism having its face parallel with the Vertical plane and its bases parallel with the Horizontal Plane.

Example 2. Revolve the prism from the position of Ex. 1, 30° to the left (counterclockwise) about an axis perpendicular to the vertical plane and passing through the lower left-hand corner obtain the three views.

Example 3. Revolve the prism from position of Ex. 2, 30° backward (away from you) about an axis perpendicular to the end or profile plane. Obtain three views.

Example 4. Revolve the prism from the position of Ex. 3, 60° counterclockwise about an axis perpendicular to the Horizontal plane. Obtain three views.

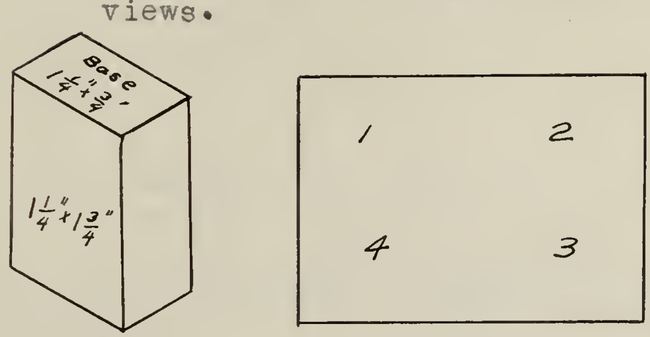


Plate 14

Divide the 10" x 14" sheet into two equal spaces and on the left half make a front, top, right side, and auxiliary view of Fig. 321, page 114 and on the left half do the same thing for Fig. 230. For Fig. 231 make an auxiliary view of the slant surface only, but for Fig. 230 change the $1\frac{1}{2}$" vertical dimension to $\frac{3}{4}$" and make a complete auxiliary view.

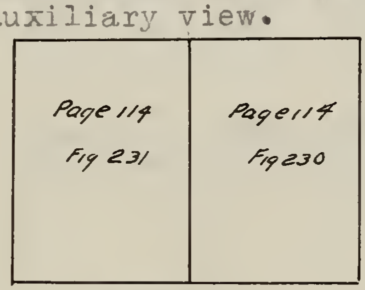


Plate 15

Draw the front, top, and side and complete auxiliary view of Fig. 233, page 115. Make the cylinder one and one-half size and change the location dimensions to give a good layout.

Plate 16

See Special Problem 2 of these notes

Plate 17

Divide the 10" x 14" sheet into four equal 5" x 7" spaces and do the following problem in the spaces indicated. Copy 4 examples from special problem 4 of notes.

1	2
3	4

Plate 18

Divide 10" x 14" sheet into 4 equal 5" x 7" spaces and do the following problems in the spaces indicated.

Problem 1. Page 139 Fig. 301. Draw the Front, top and side views, having the front view in section.

Problem 2. Page 118, Fig. 251. Draw the front and top views having the front view in section.

Problem 3. Page 143, Fig. 336. Draw the front and side views having the side view in section.

Problem 4. Page 118, Fig. 248. Draw a section view only.

1	2
3	4

Plate 19

Make a three view drawing with the front view in section of the main casting of the Jig Base, Fig. 558, Page 281. Omit 3/8" taped holes.

Plate 20

Draw the three views of Problem 45, Fig. 379 Page 167 and complete the intersection. Lay out the paper so that the Front, Top and Side views fit on the left side of the paper leaving the right side for a development of the pentagonal prism.

Plate 21

Draw the three views of Problem 46, Fig. 379, Page 167 and complete the intersection. The arrangement is left to the student.

Plate 22

Divide 10" x 14" sheet into two spaces as indicated. On the left-hand half solve problem 47 of Fig. 380, Page 167. On the right-hand half solve the front and top views of Problem 49, Fig. 380, Page 167. Change the 3/16" dimension to 7/16".

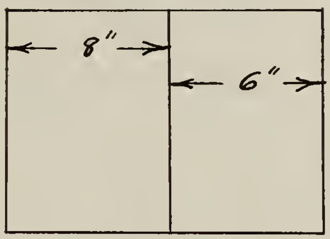


Plate 23

See Special Problem 3 of these notes.

Plate 24.

On the left side of a 10" x 14" sheet make an isometric drawing of Fig. 295, Page 138 and on the right-hand side an isometric drawing of Fig. 300 page 139. In Fig. 300 change the $1\frac{1}{4}$" round hole to a $1\frac{1}{2}$" square hole.

Plate 25.

On the left side of a 10" x 14" sheet make an isometric drawing of Fig. 321 Page 142, omitting the 3/8" radius. On the right-hand side make an isometric drawing of Fig. 297, Page 138.

Plate 26

On a 10" x 14" sheet complete the following problems in the spaces designated:

Problem 1. Make an oblique projection of Fig. 330, Page 143.

Problem 2. Make an oblique projection of Fig. 331, Page 143.

Problem 3. Make a cabinet projection (45° to the right) of Fig. 302, Page 139.

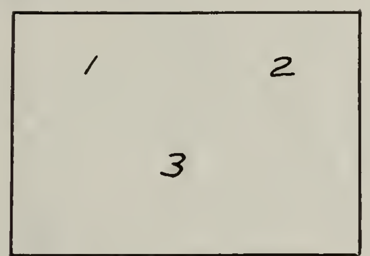


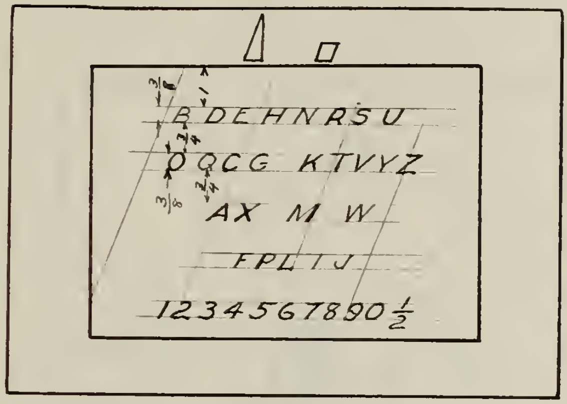
Plate 27

See Special Problem 5 of these notes.

SPECIAL PROBLEM 1.

A Careful Study of Inclined Gothic Capital Letters and Numerals.

PLATE LAYOUT.-- 1. In center of 10" x 14" place draw a 7" x 10" rectangle and rule five pairs of guide lines as shown below.

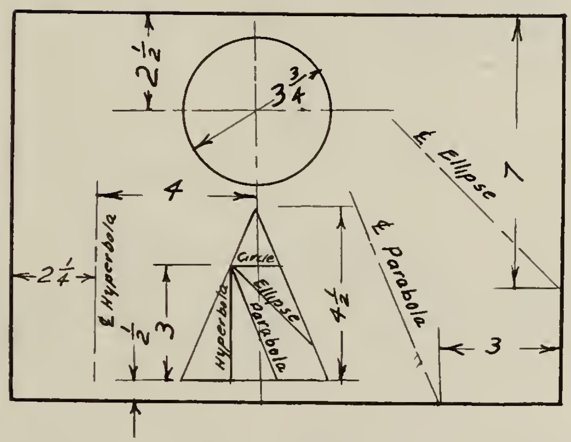


2. Rule vertical center line of plate.
3. Above the 7" x 10" space draw a triangle and parallelogram as shown, triangle to have legs 3/8" and 1", parrellogram to have same slope, and be 5/16" wide and 3/8" high. The triangle gives the proper slope and the parallelogram the proper proportions for the normal letters.
4. Across the 7" x 10" space rule four or five light lines sloping as indicated.
5. Between first pair of guide lines draw freehand, the eight normal letters, B, D, F, N, R, S, U,* estimating slope and width. See Svensen, page 18. After making each letter, test it for slope and width. Have letters about ¼" apart and center the line on the plate.--Four letters on each side of center-line.
6. Between the second pair of guide lines draw the four round letters O, Q, C, and G, also K, T, V, Y, Z., each 5½ units wide. Center the line on the plate.
7. Between the third pair of guide lines draw A, X., 6 units wide, M 6½ units, and W, 8 units wide.
8. Between the fourth pair of guide lines draw F, P, and L, 4½ units wide, I and J.
9. Fifth line to contain the numerals with a fraction.

*Letters F, P, and Z appear elsewhere.

SPECIAL PROBLEM 2.

CONE AND CUTTING PLANES

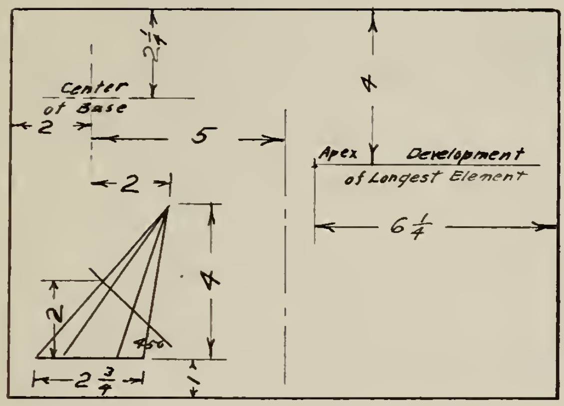


1. Draw front and top views of the right circular cone with cuts thereon as shown; the Ellipse at 45°, Hyperbola parallel to the axis, Circle and Parabola ? When determining the top view the elements of the cone are not to be used, but a more nearly accurate method of horizontal cutting planes will be used. Take planes ¼" apart.
2. Determine true size (auxiliary view) of each curve on given center line.
3. Properly name each curve in front view and in true size views.

SPECIAL PROBLEM 3

TRUNCATED REGULAR HEXAGONAL PYRAMID

1. Draw Front, Top, and Side Views and the development of the complete hexagonal pyramid, base included in development.



2. Cut off top of pyramid with 45° slope as shown. Revise all views.

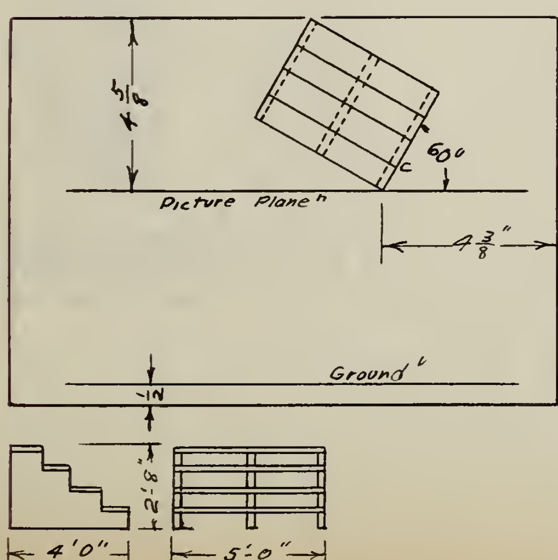
3. Draw auxiliary view of slant top, adding this to development.

SPECIAL PROBLEM 4

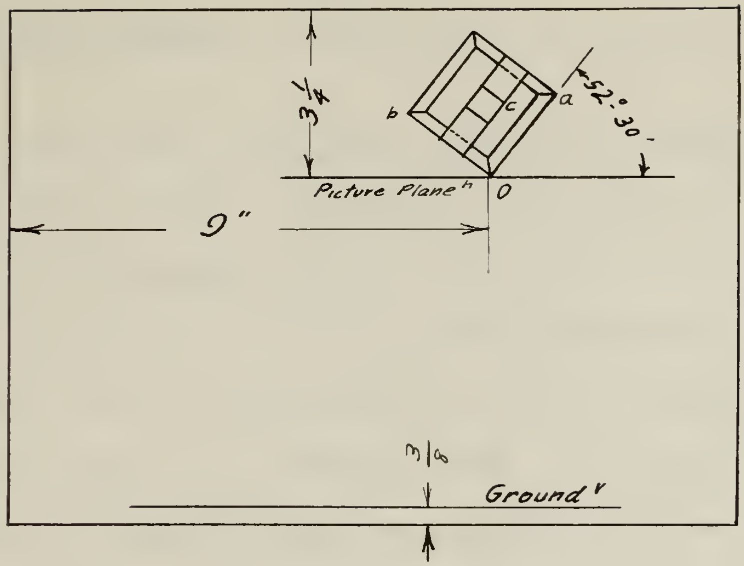
PERSPECTIVE DRAWING OF FOUR STEPS

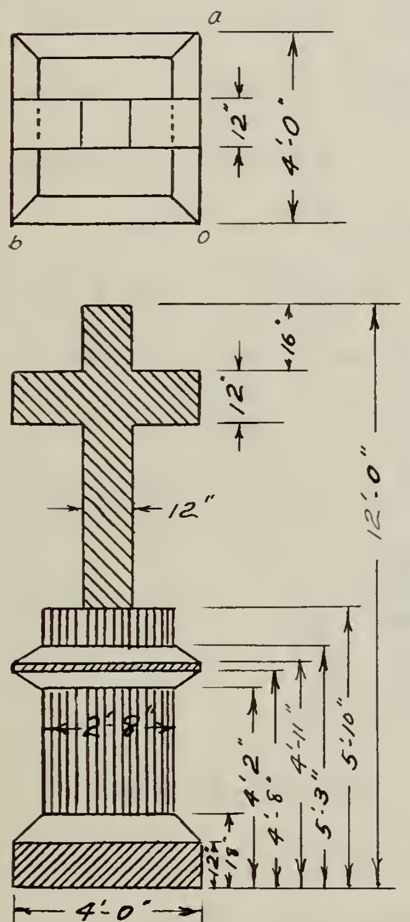
At a scale of 1/16" = 1 inch, (3/4" = 1 Ft.) make the perspective drawing of the four steps shown above, under the following conditions. The observer is to be stationed 7'-0" away from the picture plane and directly in front of point C. The horizon is 4'-9" above the ground. The steps consist of three equal upright supports 2" thick, and four planks 2" thick.

Use only one line of measurements.



SPECIAL PROBLEM 5
SPECIAL DRAWING OF A MONUMENT





At a scale of ½" = 1 ft. make the perspective drawing of the monument. Show construction, as large as possible, for the angle 52° 30'. Construct this angle again at the station point to obtain the vanishing points with greatest degree of accuracy.

Station point is 13'-0" from the picture plane and 4'-2" above the ground, and directly in front of Corner C of the cross.

Note: Use three different lines of measures--one for each of the three vertical front faces of the monument; one line for surfaces cross-hatched//////; one for surfaces ; one for surface .

CHAPTER V

The Teacher's Manual to Accompany the Course of Study.

The last chapter was very definitely concerned with setting up the course of study specifying the topics to be studied, the organization and arrangement of the topics, the problems to be done, the layout of the plates, the assignments to be completed, and the work to be accomplished for each lesson. Although stating the work to be accomplished, the course of study did not suggest methods or outline procedures for carrying out the objective of each lesson. It is the defining of this procedure that becomes the task of this chapter. In doing this we will make a teacher's manual to accompany the previously designed course of study.

In order that the manual may be most effectively used it has been so made up that a lesson plan is suggested for each lesson rather than for each topic. Although not always adhering to a set plan the following outline is the one which has been employed for the majority of lessons:

I. References
II. Aim of the lesson
III. Abilities necessary to solve the plate
IV. Illustration problem for blackboard use
V. Outlined demonstration lecture
VI. Assignment

The references have been given as offering the instructor an efficient means of familiarizing himself with the content of the lesson. The first reference applies to the class text and the abbreviation (F) represents French's Engineering Drawing book. The second reference is preceded by the abbreviation (S) standing for Svensen's book titled, "Drafting for Engineer's."

This text is constantly referred to because it is felt that it is an outstanding book giving a different point of view, and should be in the possession of every instructor of drawing. In many cases a third or special reference has been given. This has been done when there is a worthwhile treatment of the topic, by some author who has specialized in that one phase of the subject.

The aim of the lesson has been given very specifically to define at the outset just what the outcomes are to be. These serve as a guide for the instructor and when the lesson is completed he should be able to check each one as having been fulfilled that evening.

The third division lists the specific abilities necessary to solve the plate. The writer first solved all the plates and then analyzed each plate listing the specific abilities that will be used, by the student, in the solution. This has been done so that the instructor may know the minimum work to be covered. When the plate to be done is not studied in this manner the instructor is very apt to give a demonstration lecture which he thinks complete until he finds that the students when solving the class plate all ask a common set of questions the answers to which he would have previously covered had he analyzed the student's plate. These requirements allow for some lee way as well as holding one down. The instructor should first see to it that the essentials are covered and then if he wants to expand for educationally worthwhile purposes he can do so.

The illustrative problem for blackboard use in the demonstration lecture has been made up from a list of the abilities necessary to solve the next plate. The blackboard problem applies all the procedures and thought processes to a different problem than that to be done by the students. The chief dimensions have been suggested for the standard height of blackboard, (4ft.) but the minor dimensions are left to the instructor and may be closely approximated by method of proportion. When different colors are effective they are suggested.

The demonstration lecture has been outlined in a logical way to tie up the known material with the new and the new for what is to come. The lecture takes into account the aim, specific abilities, the demonstration problem and the assignment. The time limit has been suggested in two or three cases but for the rest the judement of the instructor is to be relied upon.

The lesson plans presuppose a combined lecture-laboratory method of teaching. The word lecture meaning, demonstration lecture, and laboratory implying supervised study. The demonstration lecture is to be of the informal type with the instructor working out the problems, with the students, constantly refering to previous assignments, reviewing and drilling old material by means of questioning and new applications. The teacher should teach appreciation indirectly by showing a complete mastery and live interest in the subject and directly by arousing the students in the appreciative aspects when the opportunity and type of topic allows.

The class should be limited to thirty men at the outset and be arranged according to a seating plan to save time and confusion in taking attendence and in collecting and distributing drawing plates. All plates should be corrected, graded and returned promptly to set a good example for the students and to offer them an opportunity for review. The matter of grading late plates is left to the instructor as it has been the experience of the writer that evening school students should be considered as individuals, each case differing from the other because of differences in working hours, previous training, and commuting distances. For plates that are on time the following grading plan is to be used "A" (excellent), "B" (good), "C" (fair), "D" (failure), "FF" (complete failure). When correcting plates the errors should be noted and if the technique is poor it should be indicated.

The following lesson plans and plates are offered and are to be used with the course of study for the thirty lesson course in Engineering Drawing.

Lesson 1 (Introductory Lecture)

I Aim:

1. To introduce drawing as a language.
2. To justify its place on the engineering curriculum.
3. To create an interest in the subject.
4. To check up on the equipment and interview students.

II Lecture:

A. English, mathematics and drawing, the most fundamentals that are prerequisites to a successful engineering career.

1. Why English?

(a) More failures due to faulty English than to poor design.

(b) Different meanings for the same word.

2. Why Mathematics?

(a) Basis of engineering sciences.

(b) Prove 2=1 by algebra to show that mathematics is not infallible.

3. Why Drawing?

(a) The only universal language.

B. Language--The expression of ideas by writing or some other instrumentality.

1. Articulate--Read by ear.

2. Mechanical--Read by ear.

(a) Telegraph, Bells, Whistles, Guns, Bugles, Drums

3. Motion--Read by eye.

(a) Wig-wag, Heliograph

4. Non-motion--Read by eye.

(a) Flags, Lights, Fires and Smoke.

5. Recorded--Read by eye.

(a) Telegraph, Music, Shorthand, Mathematics.
(b) Sculpture, pictures, drawings.
(c) Brail (read by touch)

6. Picture Language

(a) Egyptian, Asyrian, Greecian, American, Indian.

(b) Chinese--

人 亻 (Man)

大 Great (one-man-greatest thing created)

天 Heaven (Greater than man--something above man)

田 Fields, farm.

佃 Farmer (man and farm)

口 Box

囚 Prisoner

口 Mouth

言 Word (Something coming out of the mouth)

信 Honesty (Man standing by his word)

耳 Ear

門 Door

閂 Lock (Close-shut-bar)

開 Open (Remove bar)

聞 Hear (Ear at door)

問 Ask (Mouth at door)

女 Woman

女女女 Slander, gossip, scandle (Three women)

仁 Kind (Two men)

子 Male child

好 Good (Woman and male child)

日 Sun

 Moon

 Morning (Sun over horizon)

 Bright (Sun over moon)

C. Pictures --A universal language.

1. Magazine cover good illustration
2. Child's picture book
3. Moving pictures
4. Descriptive geometry
5. On one side of a large card print in five different languages the word "house" and see how many in the class can read any of them. On the reverse side have a picture of a house to which the response will be universal.

D. History and development of engineering drawing.

1. 1795 Gaspond Monge

   1821 Crozet

   Dean Anthony's contribution (Change from first to third quadrant)

2. 1860-1870--Patent office began to require drawings instead of models.

E. Opportunities for draftsman.

1. The United States Bureau of Labor Statistics give the following classifications and duties:

   (a) Detailer, whose duties are to draw in detail from a general drawing the parts of any machine.

   (b) Machine Designer, whose duties are to design new machines or attachments.

   (c) Mechanical Draftsmen, whose duties are to make drawings, of machines, or from sketches or data furnished by the designer.

   (d) Tool Designer, whose duties are to design tools or jigs for performing special operations.

(e) Tracer, whose duties are to copy drawings by tracing them with ink on transparent glazed cloth or with pencil on transparent paper.

F. Assignment

1. Read (F) Arts 1 and 2.

2. Study (F) Arts 5 to 15.

G. Inspect equipment that the students have purchased outside of the school to see if it meets the requirements.

H. Interview those students who have special problems.

Lesson 2 (Technique Practice)

I References (F) pp 13-32 (S) pp 1-11.

II Aim:

1. To familiarize the students with the instruments and materials to be used and offer practice in instrumental drawing technique.

III Specific abilities necessary to solve the class plate are:

1. To be able to lay out the plate properly.

2. To be able to use accurately the following equipment:

   scale 30° and 60° triangles, bow dividers, large compasses and bow compasses

3. To be able to draw even weight straight horizontal and vertical lines either full or dotted and to acquire the ability to make even spacing by eye.

IV Demonstration Lecture:

1. The importance of having a standard plate size and layout.

2. Testing the "T" square and triangles for accuracy.

3. The proper use of the "T" square.

   (a) Left-hand side of board for right-hand men.

   (b) "T" square is always in horizontal position but may be used as a rest for triangles in making parallel lines.

4. The use of the triangles.

   (a) To draw parallel and perpendicular lines.

   (b) How to draw lines longer in length than the edge of the triangles.

5. The use of the dividers and compasses.

   (a) Trial and error method.
   (b) Divider points do not go through the paper.
   (c) Drawing a large circle.
   (d) Importance of good tangent points.

6. How to draw straight and dotted lines.

7. Dividing a space evenly without the use of a scale.

8. The limitations of each grade of pencil and how to sharpen them.

    A. 6H pencil (instrumental work)
    2H Free-hand work and lining in border lines when plate is completed.

    B. For sharpening of pencil refer definitely to (F) Fig. 17 page 14.

V The actual handling of instruments can best be taught by careful individual instruction but a little preliminary demonstration work on the part of the instructor will save much time for the students and prevent many false and awkward movements. Each point should be fully demonstrated by the use of the actual materials or when possible by the blackboard equipment. This lecture demonstration should not extend over a period of forty minutes in length.

VI Assignment

A. Complete Plate 1.

B. Study (F) Arts 42 to 59 and learn all constructions.

Lesson 3 (Geometric Constructions)

I References (F) pp 60-80 (S) pp 28-36

II Aim:

1. To provide further practice in the use of instruments

2. To acquaint the student with geometrical constructions commonly used in further drawing work.

3. To give thought provoking exercises as well as drill work.

III Specific abilities necessary to solve the class plate are:

1. To be able to follow written directions accurately.

2. To divide graphically a given line into any desired number of equal parts.

3. To know how and be able to construct a pentagen within a circle.

4. To draw a circle of known radius tangent to 2 given lines.

5. To construct a hexagon having either the side, long diameter or short diameter given.

6. To construct by means of the triangles and "T" square only, any angle that is a multiple of 15°.

IV Demonstration Lecture:

1. Essential parts of a problem

   (a) What is given
   (b) What is wanted
   (c) How to solve it.

2. To illustrate how to follow directions to solve a problem similar to (F) Fig. 105 Page 61.

3. Demonstrate by means of the blackboard "T" square and triangles how to obtain any angle that is a multiple of 15°.

4. Construct on the blackboard a regular hexagon having its long diameter making an angle of 15° with the horizontal and thirty inches in length.

V Assignment

Complete plate 2

Read (F) Arts 21 to 33 (inclusive)

PLATE

McGIVERN J.G.

Lesson 4 (Lettering)

I References (F) pp 34-59 (S) pp 12-27

Special References, Daniels F. T. "A Text-book of Free hand Lettering" Boston, D. C. Heath & Company, 1907.

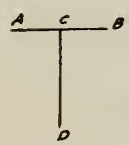
II Aim:

1. To learn the proportions of the upper case inclined Gothic letters and numbers.

2. To acquire skill and speed in doing lettering of the inclined Gothic type.

III Demonstration lecture:

1. Before going into a detailed study of the form of the letters, it would be well to consider certain optical illusions which must be guarded against if we are to make our lettering look uniform.

A. 

"AB" appears shorter than its equal "CD". The letter "T" to appear average must have its horizontal line longer than the normal width of a letter.

B. 

Diameter of circle appears smaller than the side of the square. The circular letter must be made slightly wider than normal to appear normal.

Cross looks narrower than the square so that letters of the "X, K, Y, V" type must be made wider than normal.

"BC" appears longer than its equal "AB", therefore, letters similar to "FPL and J" must be made narrower to appear the same width as a normal letter.

2. In as much as lettering is a drill and appreciation subject without offering an opportunity for problem solving, the instructor can best teach the lettering forms by solving, before the class, the exact plate that they are later to do. This classification of the letters, with respect to their relative widths, is consistant with the above optical illusions and is taken directly from page 150 of Professor G. C. Anthony's "Introduction to the Graphic Language",

published by D. C. Heath & Company of Boston in 1922.

3. The normal letter has a width equal to five-sixths of its height. The slant used will be that recommended by French and is 2 5. For blackboard work make the letters three inches high giving a unit equal to one-half an inch. Draw in, lightly, freehand the parallogram of the correct width into which each letter is to be put.

4. Explain the relation between "Y, U and W."

    1. Take up the construction of the numbers.

5. Lower case letters:

    A. Height of the body equals two-thirds the height of the upper case letter.

    B. The C, K, O, S, V, W, X, Z group is identical in form to the upper case letters.

        (a) The "K" is included, although its back is lengthened to the height of a capital.

    C. The a, b, c, d, e, g, o, p, q group are made from "c" as a base by adding straight lines or by leaving out a portion.

    D. The n, h, u, r, m group are similar.

    E. The l, i, j, t, f group have practically no width.

6. The essence of good lettering.

    1. Constant slope

    2. Proper proportions

    3. Proper forms.

V Assignment

1. Complete plate 3

2. Study (F) Arts 80 to 88 (inclusive)

B D E H N R S U

O Q C G K V Y T Z

A X M W

F P L I J

1 2 3 4 5 6 7 8 9 0 $\frac{1}{2}$

[illegible]

Lesson 5 (Orthographic Projection)

I References (F) pp 81-90 (S) pp 44-53

II Aim:

1. To teach how to represent the size and shape of a simple object by three views.

2. To teach how to place the views on the plate.

III Specific abilities necessary to solve plate

1. To know the meanings of the three projections.

2. To be able to visualize to the extent of being able to work out the views when given the object or a pictorical of the object.

3. To know that a visible edge is represented by a full line and an invisible edge by a dotted line.

4. To be able to represent a circle in projection.

IV Illustrative problem for blackboard use.

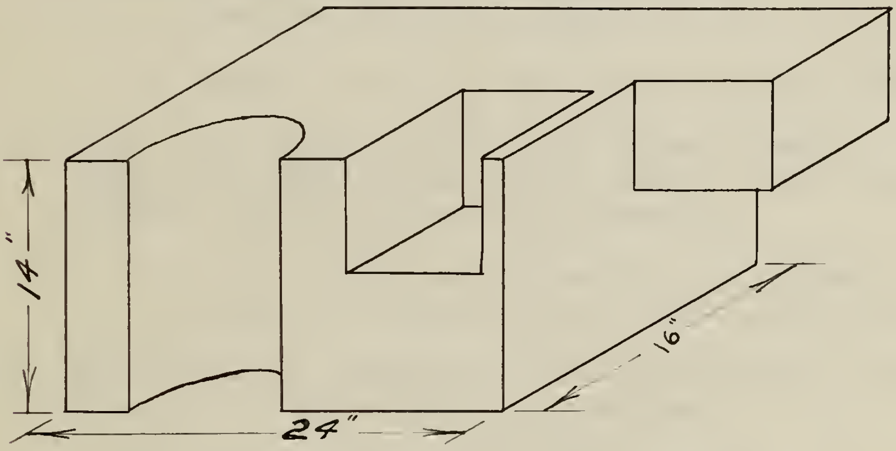


Fig I

1. On the blackboard make a pictorical drawing of the above object.

2. From this pictorical draw the top, front and side views.

3. Only the three principle dimensions are given. All lines not dimensioned may be determined by proportion.

V Demonstration Lecture

1. Meaning of the word, orthographic

   A. Orthos-right, Graphen-write, Gonia angle

   B. More correct than the word, "orthographic" would be orthognal (right angle) but its use is not very common.

2. Questions on the assignment

   A. Uses of three view drawing

   B. Are three views always necessary?

      (a) Illustrate by a square and triangular prisms, together with a circular cylinder.

   C. How are the views placed with respect to each other?

   D. What are their relative proportions?

3. Draw free hand on the board three views of familiar geometrical solids such as the cube, cyliner, cone, sphere and pyramid.

   A. Have voluntiers from the class tell what the shape of the views will be.

4. Solve on the blackboard, with the help of the class, the demonstration problem.

   A. Stress the following points.

      (a) All visible edges are represented by full lines, all invisible edges by dotted lines.

      (b) The top view is always directly over the front view.

      (c) The side view is always on the same level as the front view.

      (d) The width of the front equals the width of the top view.

      (e) The height of the front equals the height of the side view.

(f) The length of the side equals the length of the top view.

5. Explain how to lay out a problem on a plate.

A. Illustrate by referring to one of the home work problems.

VI Collect the plates five minutes before the close of class.

1. Use remaining time for discussing home work problems.

VII Assignment

1. Solve plate 5

2. Study (F) Arts 229 to 238 (inclusive)

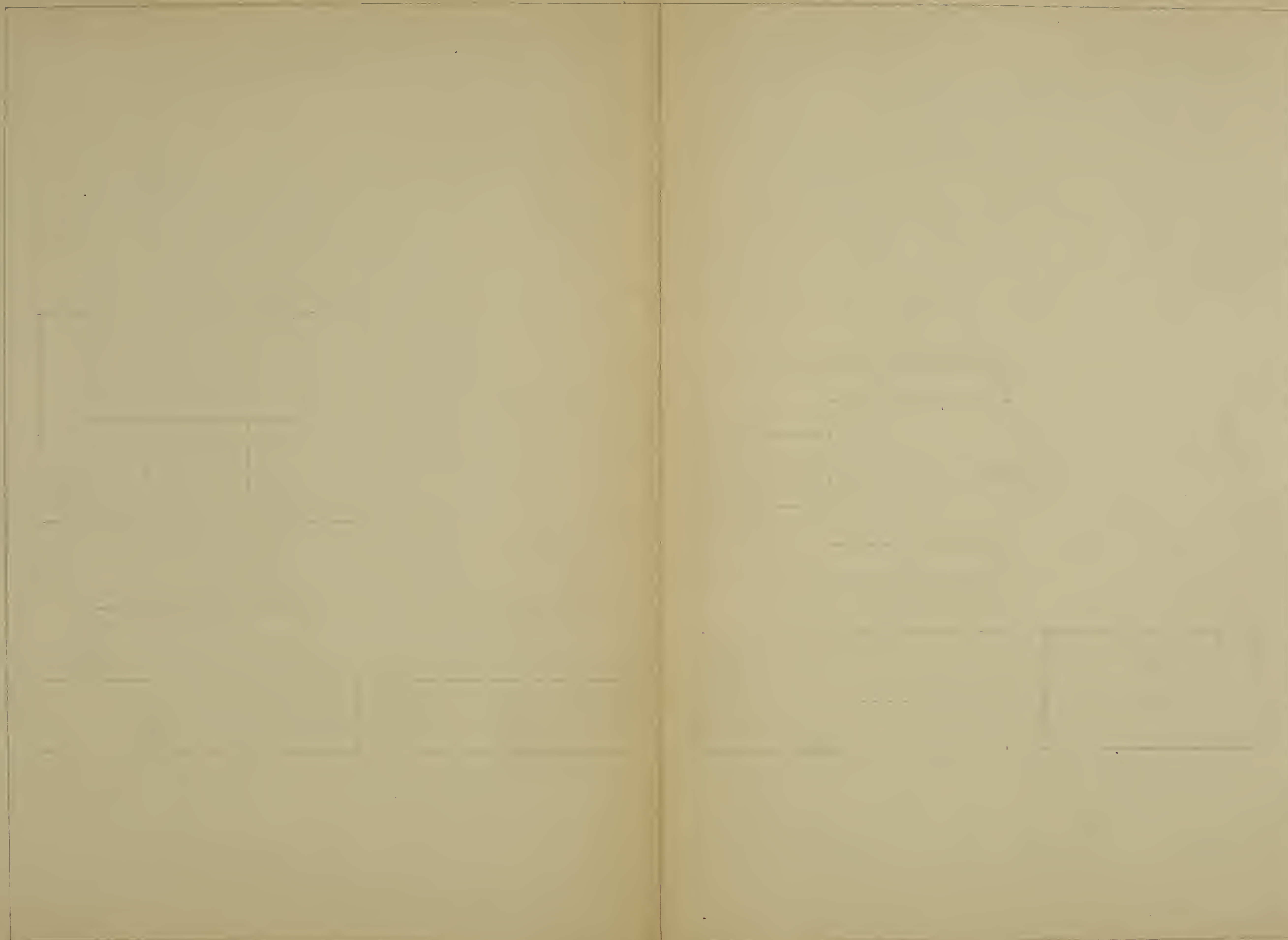
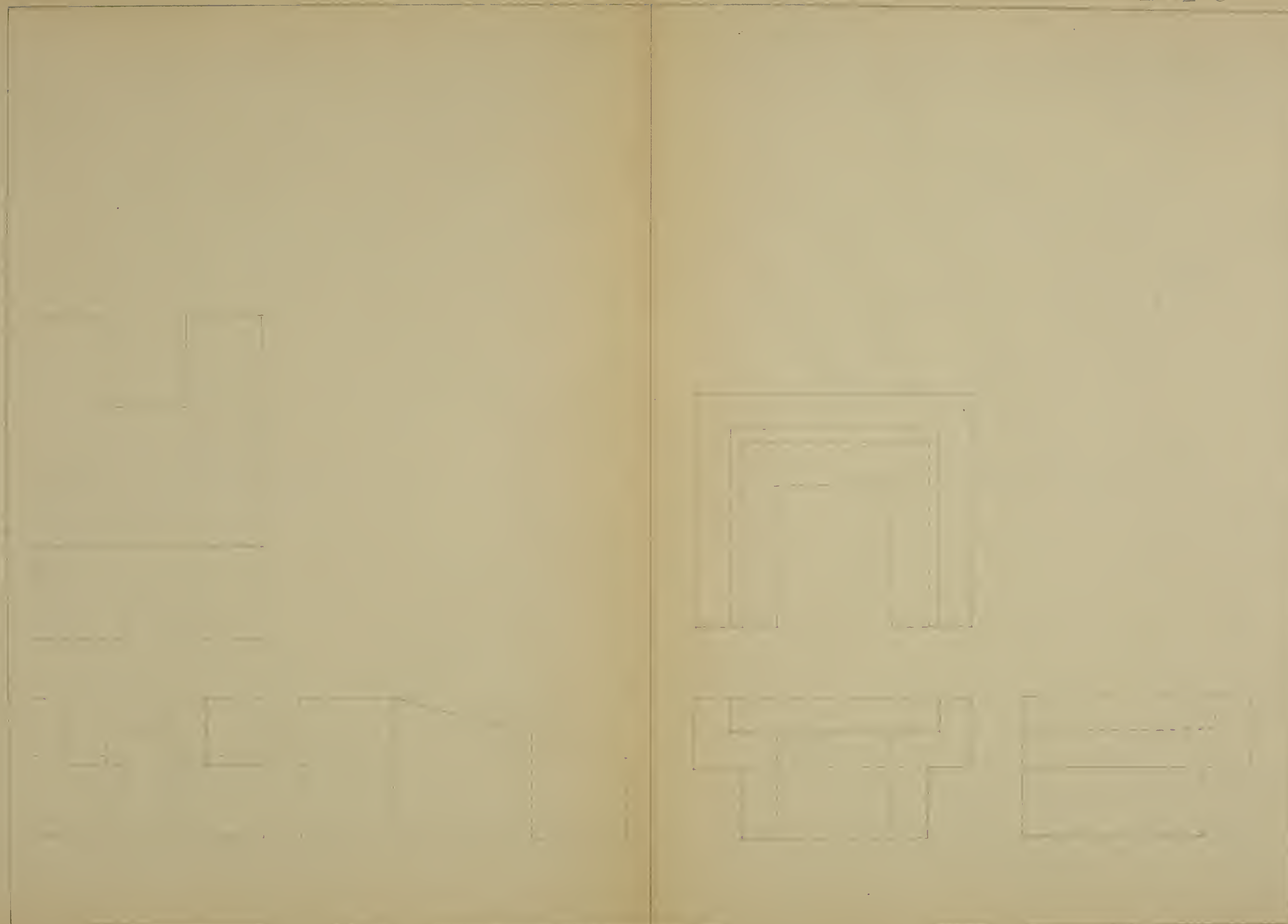


PLATE 5



McGOVERN J.F.

Lesson 6 (Orthographic projection and free-hand sketching)

I References (F) pp 296-307 (S) pp 119-128

Special Reference--Zipprich A. E. "Free-hand Drafting" New York, D. Van Nostrand Company, 1924.

II Aim:

1. To provide for further practice in three view drawing.

2. To teach the fundamentals of technical sketching as applied to orthographic projection

3. To guide the students in their efforts to co-ordinate the hand and eye for the correct size and shape of an object represented by three-view, free-hand drawing.

III

Specific Abilities necessary to solve plate

1. Knowledge of the fundamental principles of projection.

2. Steady hand.

3. Good sense of space proportion.

IV Illustrative problem for blackboard use.

Make a three view free-hand drawing of (F) page 307 Fig. B.

V Demonstration lecture

1. Uses for technical sketching

A. Used by the designer for preliminary design.

B. To represent machine parts that are a great distance away.

C. To convey information to the draftsman.

D. Offers valuable training in the observation of details.

2. Kinds of sketches.

   A. Memory sketching
   B. Creative or design sketches
   C. Sketching from an object

3. Materials for sketching

   A. 2 "H" pencil
   B. Speak of the use of sketch pads.

4. Free-hand drawing technique

   A. Drawing a horizontal and vertical line

   B. Drawing a circle

   C. Off-set method for sketching irregular curves

   D. Methods for obtaining proper proportions

      (a) Blocking in
      (b) Estimating relative measurements.

5. Demonstration lecture

   A. Have the students open their texts to page 307 and decide with them the various proportions of the object as you work out the problem.

   B. Previous to drawing in the details decide on the total width which will fix all other sizes. Block in the outline first.

   C. When the time is appropriate stress the fact that the front view must be completed before the true length of the front edge of the boss can be obtained in the top view.

   D. Work lightly at first and line in the work when completed.

      (a) Do not erase any construction lines.

VI Collect Plate 6 five minutes before the end of class.

VII Spend the last five minutes in looking over the home work problems with the students.

VIII Assignment

Solve plate 7
Study (F) arts 33 to 35 (inclusive)

PLATE 6

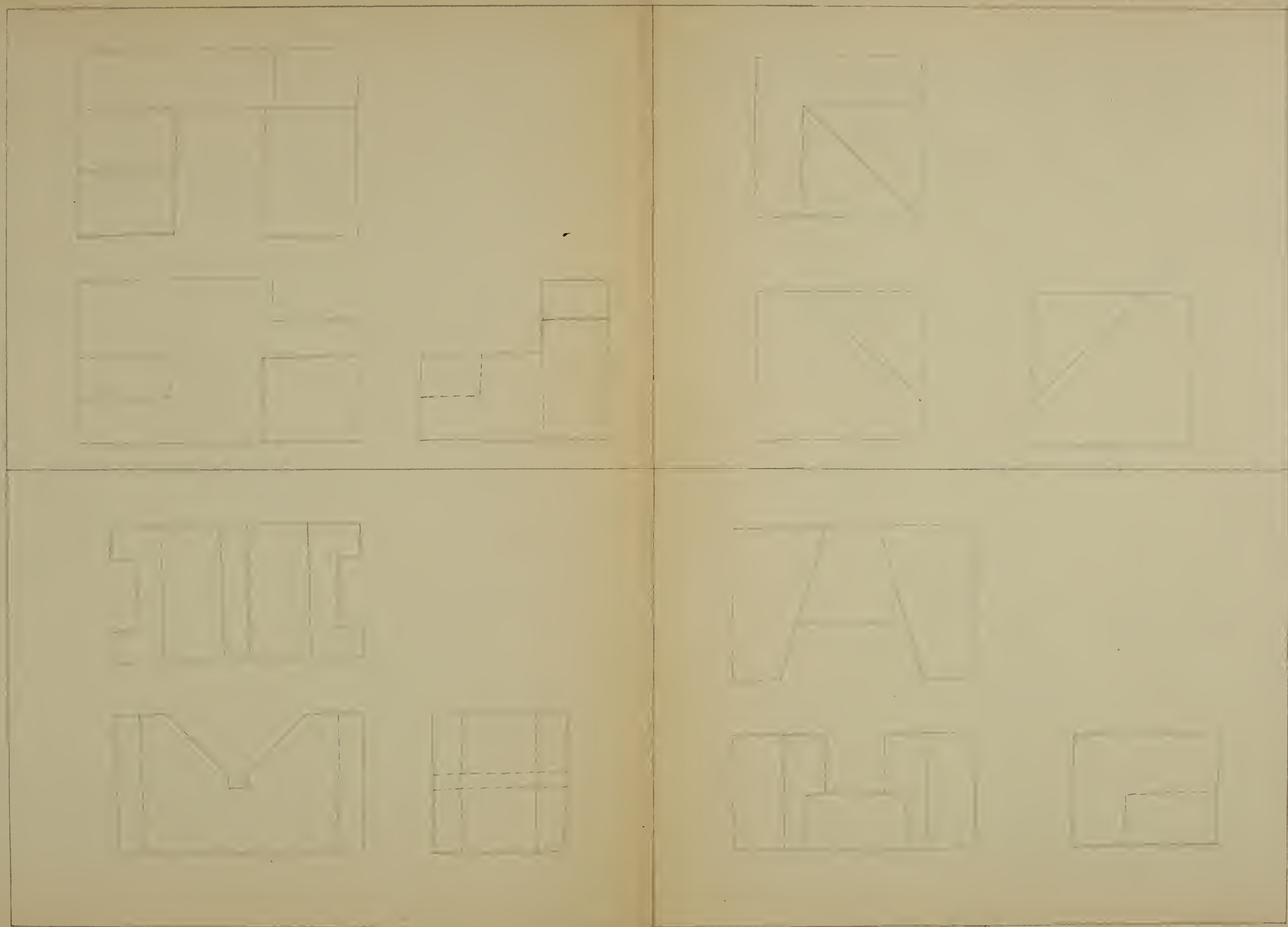
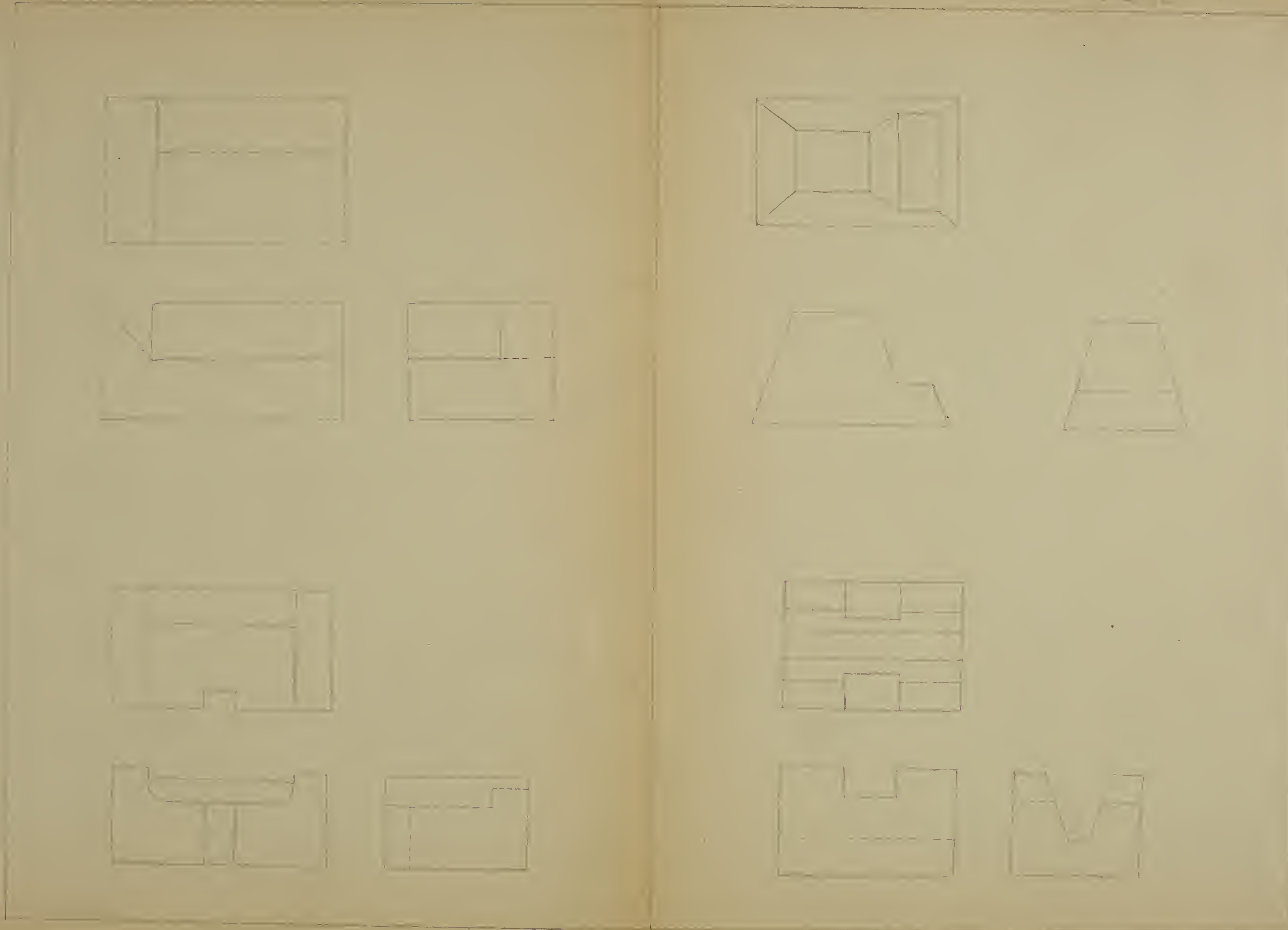


PLATE 7



M^c GIVERN L.G.

Lesson 7 (Spacing of letters and Title Design)

I References (F) pp 45-48 (S) pp 19-22

II Aim:

To learn the principles and be able to apply the correct spacing of letters for framing words, the spacing of words in sentences and the arrangement, composition and design of titles for drawings.

III Specific abilities necessary to solve plate.

1. To know the forms and to be able to do credible lettering of the inclined Gothic type.

2. To know the conventional spacing between words and between lines

3. To be familiar with the various shapes used in title design

4. To know the use of and the information to be contained in a title.

IV Illustrative title design to be solved on the blackboard.

Design a title for the drawing of a connecting rod end of a horizontal steam engine that was drawn to one quarter size. Have the largest line of lettering two inches high and select the triangular symmetrical type of composition as follows.

Horizontal Steam Engine
Connecting Rod End
Scale. . .3"=1"
Dec. 9, 1931

V Demonstration lecture

1. Use of titles

Gives necessary information concerning a drawing

2. Spacing of letters into words

A. Must be so spaced that all the letters go together as one unit to form the word.

(a) HILT

The word hilt is evenly spaced but due to the large space between the left-hand stem of the "L" and the vertical line of the "T" it does not look like one word.

HILT (correct)

B. Common letter combinations such as "the, no, and, is" when appearing as part of another word must be well placed.

(a) Illustration--NOWHERE--may, if improperly spaced appear like NOW HERE giving an exactly different meaning.

C. Spacing of words into sentences.

(a) Allow a space equal to that of a letter between words.

D. Spacing of lines

(a) The distance between two lines is equal to the height of the smaller of the two lines.

E. The shapes in symmetrical composition.

F. Illustrate title design by means of the illustrative problem.

(a) Write out the information and count the letters and spaces in the lines.

(b) With the center of each line on the center line of the title select the best form of composition.

(c) Measure over the correct number of spaces and start the first line.

(d) If the first line is not located exactly in the center have the other lines symmetrical with the first line.

VI Assignment

1. Complete Plate 8.

JACKETED KETTLE

MAIN BRONZE BEARING

SCALE ———————— FULL SIZE

DECEMBER 9, 1931

McGIVERN

Lesson 8 (Dimensioning)

I References (F) pp 171-187 (S) 64-72

Special Reference

Svenson C. L. "Machine Drawing" pp 59-72
New York, D. Van Nostrand Co. 1928.

II Aim:

1. To provide further practice in orthographic projection.

2. To teach the principles of dimensioning.

III Specific abilities necessary to solve plate are:

1. To be able to do a fairly complicated three view drawing.

2. To understand and be able to apply the theory of dimensioning.

3. To know the meaning of such common shop terms as, finished surface, drill, and counterbore.

IV Demonstration problem for blackboard use

1. Make a three view dimensioned drawing of (F) Page 104 Fig. 200.

2. Make the blackboard drawing six times the actual size.

3. Block out the problem on the board before class as a means of saving class time.

V. Demonstration lecture on dimensioning

1. Purpose of dimensioning

(a) Describe shape
(b) Describe size
(c) To give information as to method of manufacture.

2. Notation of dimensioning
(a) Extension lines
(b) Dimension lines
(c) Arrow points
(d) Leaders
(e) Figures

3. Common shop terms

    (a) Duties of the draftsman with respect to pattern shop, foundry, and machine shop.

    (b) Methods of finish.

    (c) Drilling, boring, reaming and counterboring, spot facing and grinding.

4. Location dimensions

5. Size dimensions

6. Rules for dimensioning

    (a) (F) Page 177

7. In doing the demonstration problem many of the preceding points can be applied.

8. Care should be taken not to adhere to any one of the set systems of dimensioning, but to use a combination that best suits the particular problem at hand.

VI Assignment

Study (F) arts 143 to 155 (inclusive)

Dimension Plate 9

Lesson 9

I References

Same as for Lesson 8

II Aim:

To provide for further practice in orthographic projection and dimensioning.

III Procedure.

Have the students lay out the three views of Plate 10 while you are laying out on the board the problem contained on plate 9. When the three views on the blackboard are completed call the class to attention while you dimension the problem they have just turned in. Be sure and give a reason for every practice selected as there is no one-set method for dimensioning a particular object. This should take about twenty minutes and is all the formal talking necessary for this lesson with the exception of speaking at the end of the class of the two-hour examination to be given the next lesson.

IV Assignment

General review of work to date.

Lesson 10

Two-hour examination

Assignment

Start plate 11. Layout front and top views and in the upper right-hand corner design a suitable title.

3
1
1/2
2 1/2

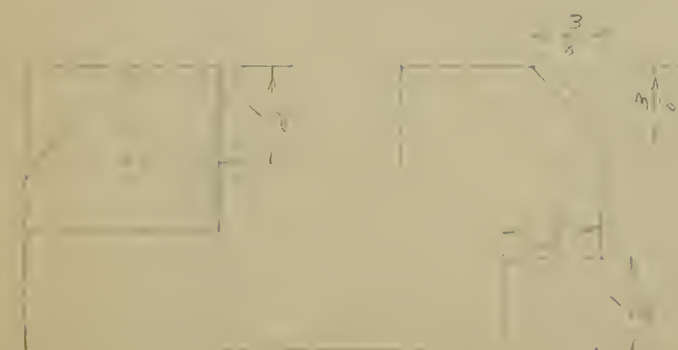
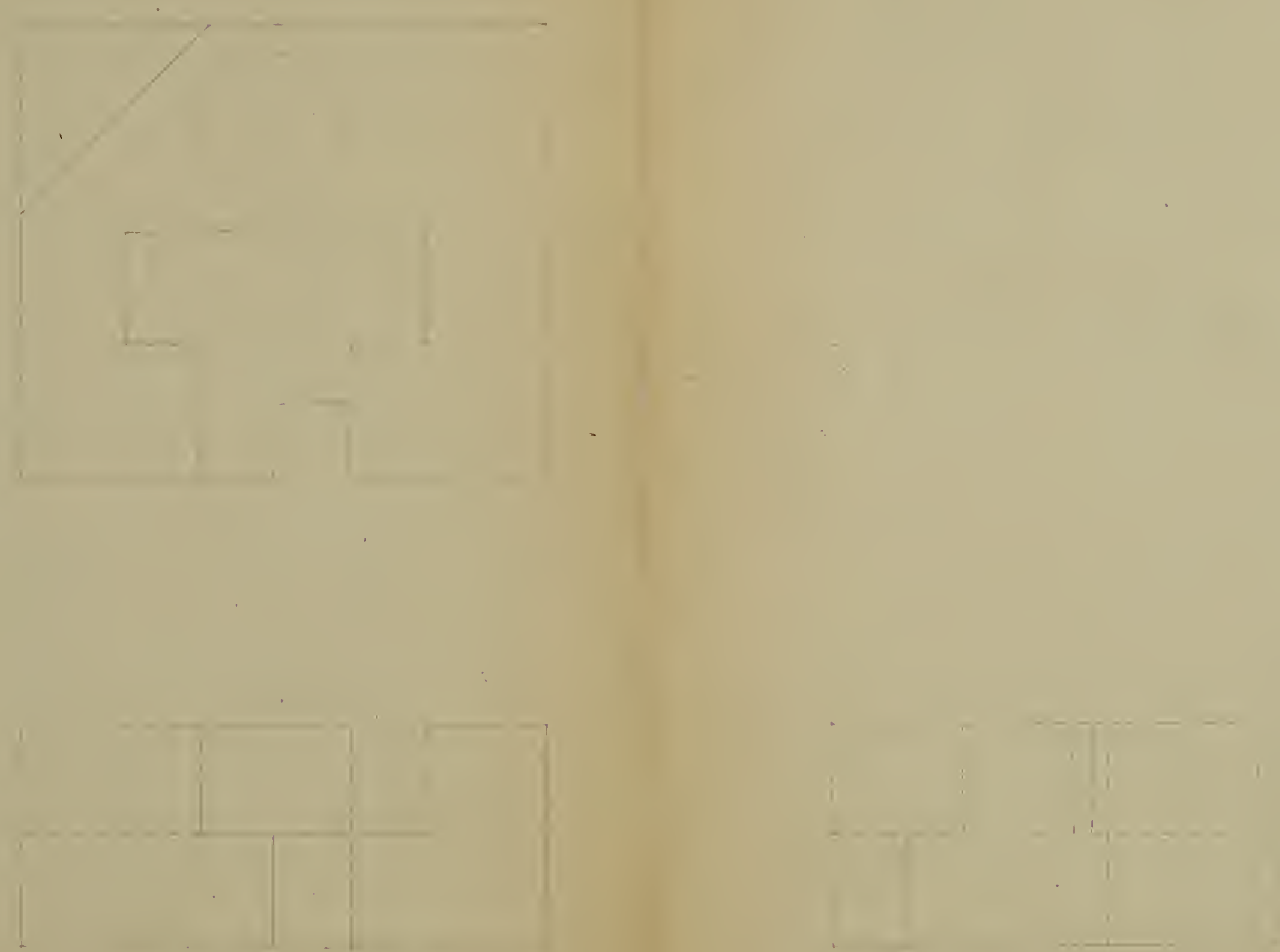


PLATE V



Lesson 11 (Orthographic Projection--
To secure a three view
from two given ones.)

I Aim:

1. To teach orthographic projection by means of a reference plane.

2. To be able to determine a third view when given two other views.

3. To introduce the reference plane method as a basis for further work in revolution and auxiliary views.

II Specific abilities necessary for solving class plate.

1. To be able to locate the third projection of a point in space when given the other two.

2. To be able to connect the points in the proper order and determine the visibility of the lines.

III Illustrative problem for blackboard use.

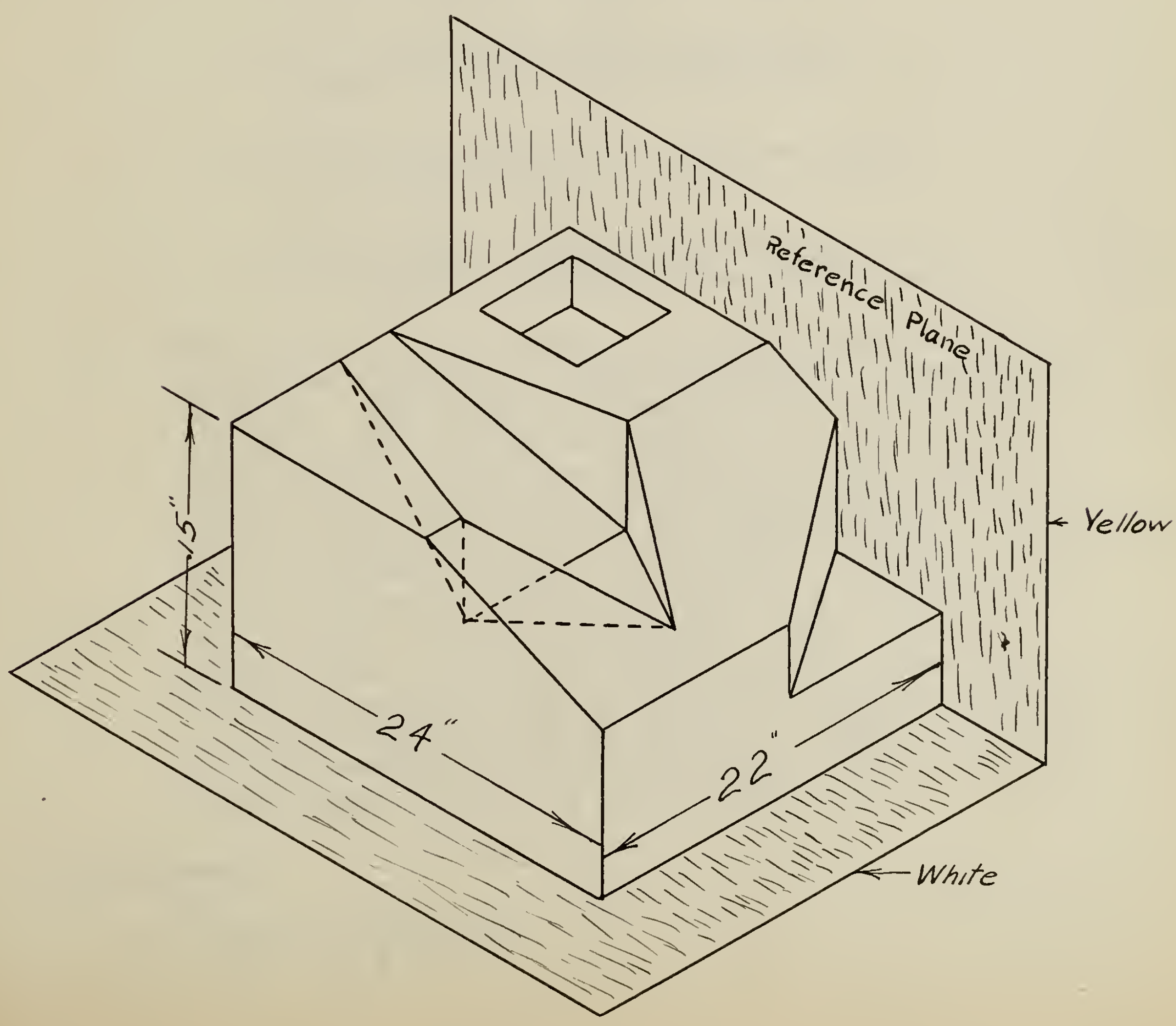


Fig 2

On one side of the blackboard make a pictorical illustration similar to the previous drawing. On another portion of the board make a top and front view. From these two views make a side view by measuring the width from the reference plane and the heights from the front view. Make frequent use of the pictorical drawing to illustrate how the points can be located in space by means of the planes of reference.

Shade in the vertical plane with yellow chalk and the horizontal plane with white chalk.

IV Demonstration lecture

1. Uses:

   1. To determine a third view from any two complete views.

   2. To finish partially completed views.

   3. To form a basis for further study in projection.

   4. To reduce a thought procedure to a definite method of the drill type.

II. The work of this lecture is concerned entirely with the solving of the blackboard illustrative problem. For sake of clearness it is well to letter a few points on the pictorical and the same points on the two original views. These points can then be obtained separately by means of the reference plane and later connected up in the proper order. It is well to stress this method as being of great help in solving the home plate that is to follow. This idea of abstracting points and line and locating them without considering, at the time, their relation to the complete view is laying a basis for the work on revolution and auxiliary views which is to be taken up as the next topic.

V Assignment

1. Complete plate 12
2. Study (F) Art 93

Lesson 12 (Revolution)

I References (F) pp 95-97 (S) 58-61

II Aim:

To teach the methods by which an object may be revolved oblique to a given plane at a definite angle or be counter revolved from the oblique to a parallel or perpendicular position.

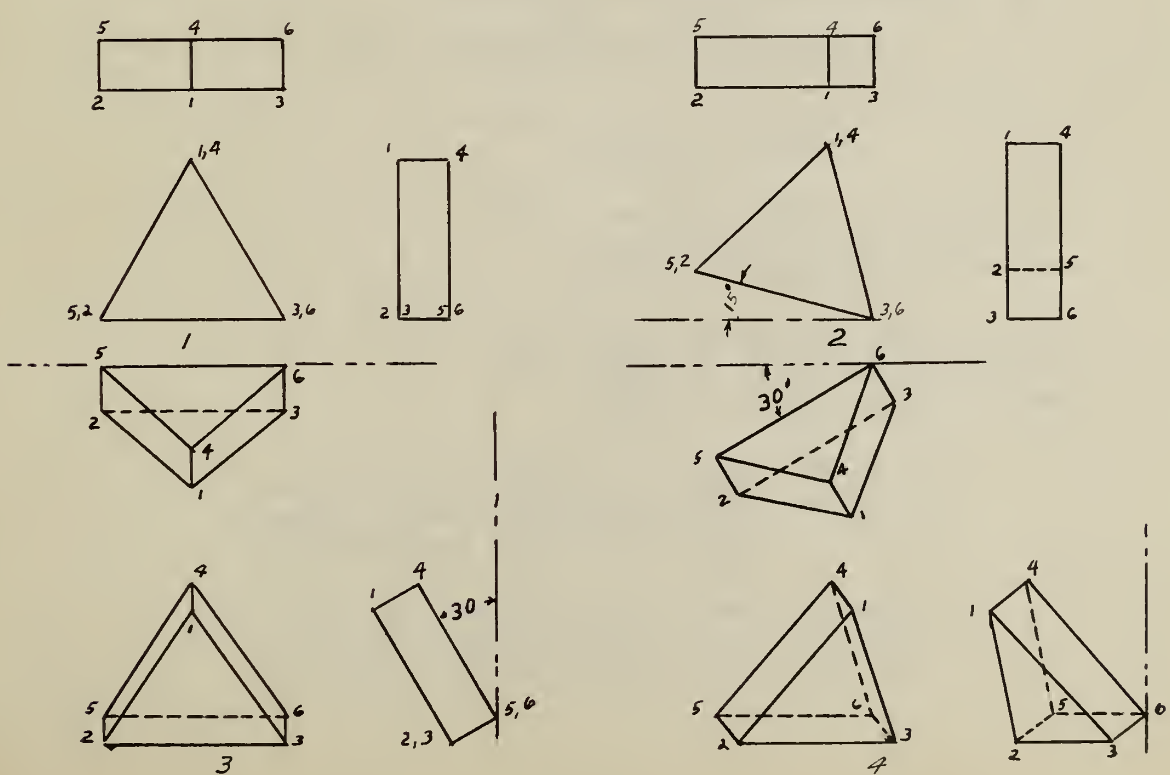
III Abilities necessary to solve plate:

1. A working knowledge of the reference plane method of completing views.

2. To know what views do not become altered in size when revolved about axis perpendicular to either the horizontal, vertical or profile planes of projection.

3. To know what views do not change their width or what views do not change their heights, or others their thickness when revolved about axis perpendicular to the principle planes of projection.

IV Illustrative problem for blackboard use:



1. Make three views of an equilateral triangular prism 10" on a side and 4" thick.

2. Prism revolved 15° clockwise about an axis perpendicular to V.

3. Revolve object from example 1, 30° forward about an axis perpendicular to profile plane.

4. Revolve object from position of example 3, 30° counterclockwise about an axis perpendicular to the horizontal plane.

Use yellow chalk for the front face, (1, 2, 3), and white chalk for the back face, (4, 5, 6).

V Demonstration lecture:

1. By means of a book show that by revolving it about an axis perpendicular to the vertical plane (blackboard) the front view changes in position only, and not in size.

   (a) The side view changes in height but not in thickness.

   (b) The top view changes in width but not in thickness.

   (c) Developmental questions

      (a) What view shall we start with and why?

      (b) The new width of the top view is the same as the width of what other view?

      (c) The new height of the side view is the same as the height of what other view?

2. Number the corners and complete the second part of the problem inviting suggestions from the class.

3. Have the students tip their books forward about an axis perpendicular to the profile plane (side wall).

(a) What view does not change in size?

(b) What view or views do not change in width?

(c) As the width of the front and top is the same as in the first problem, locate them directly underneath and project straight down.

(d) Set up a reference plane in back of the side and top view. Locate the corners and connect them up to form the new revolved position?

4. Have the students, with their books tipped forward, revolve them counterclockwise about an axis perpendicular to the horizontal plane (the floor).

   (a) After having the students discover that the top remains unchanged in size, copy the top view in its revolved position.

   (b) Draw the new front view by obtaining the heights from problem 3 and widths from top view.

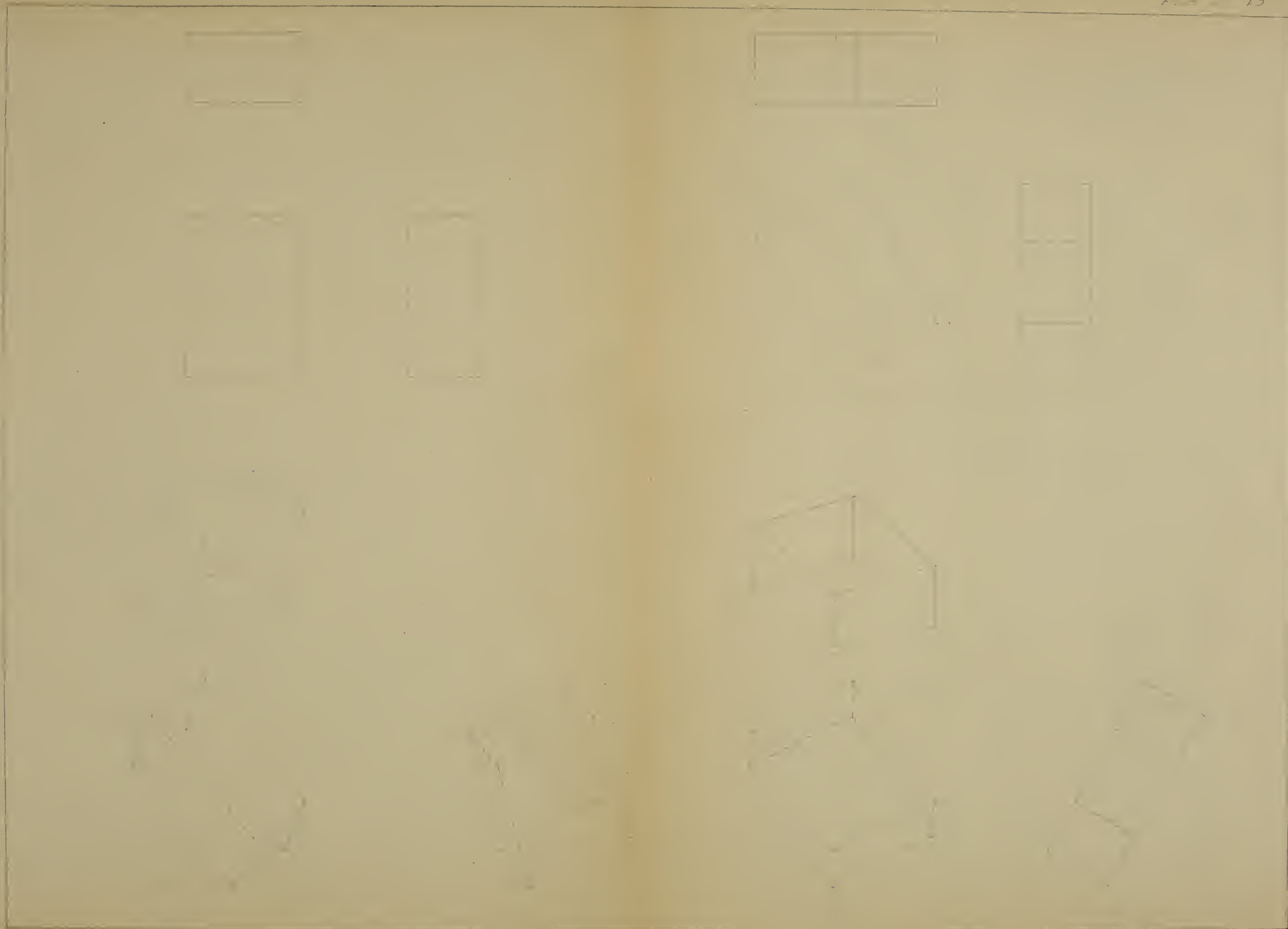
   (c) Set up a reference plane and draw the side view getting the thickness from the top view and the heights from the front view.

5. Spend a few minutes in the analysis, with the class, of their plate.

VI Assignment:

1. Complete Plate 13
2. Study (F) Arts 89 to 92 (inclusive)

[illegible]



Lesson 13 (Auxiliary Views)

I References (F) pp 90-95 (S) pp 54-58

Special References

Hood G. J. "Geometry of Engineering Drawing" New York, McGraw Hill Book Company, 1926.

The instructor's attention is called to this text as Prof. Hood has used the auxiliary view method for the solution of all the problems in Descriptive Geometry.

II Aim:

1. To teach the auxiliary view method as a means of obtaining the true size of a surface that is oblique to the principle planes of projection.

2. To show by the auxiliary view the relation of that surface to the complete object.

III Abilities necessary to solve plate:

1. A good working knowledge of the principles of orthographic projection.

2. The ability to select a plane parallel to a surface that is oblique to one plane of projection.

IV Illustrative problem for blackboard use:

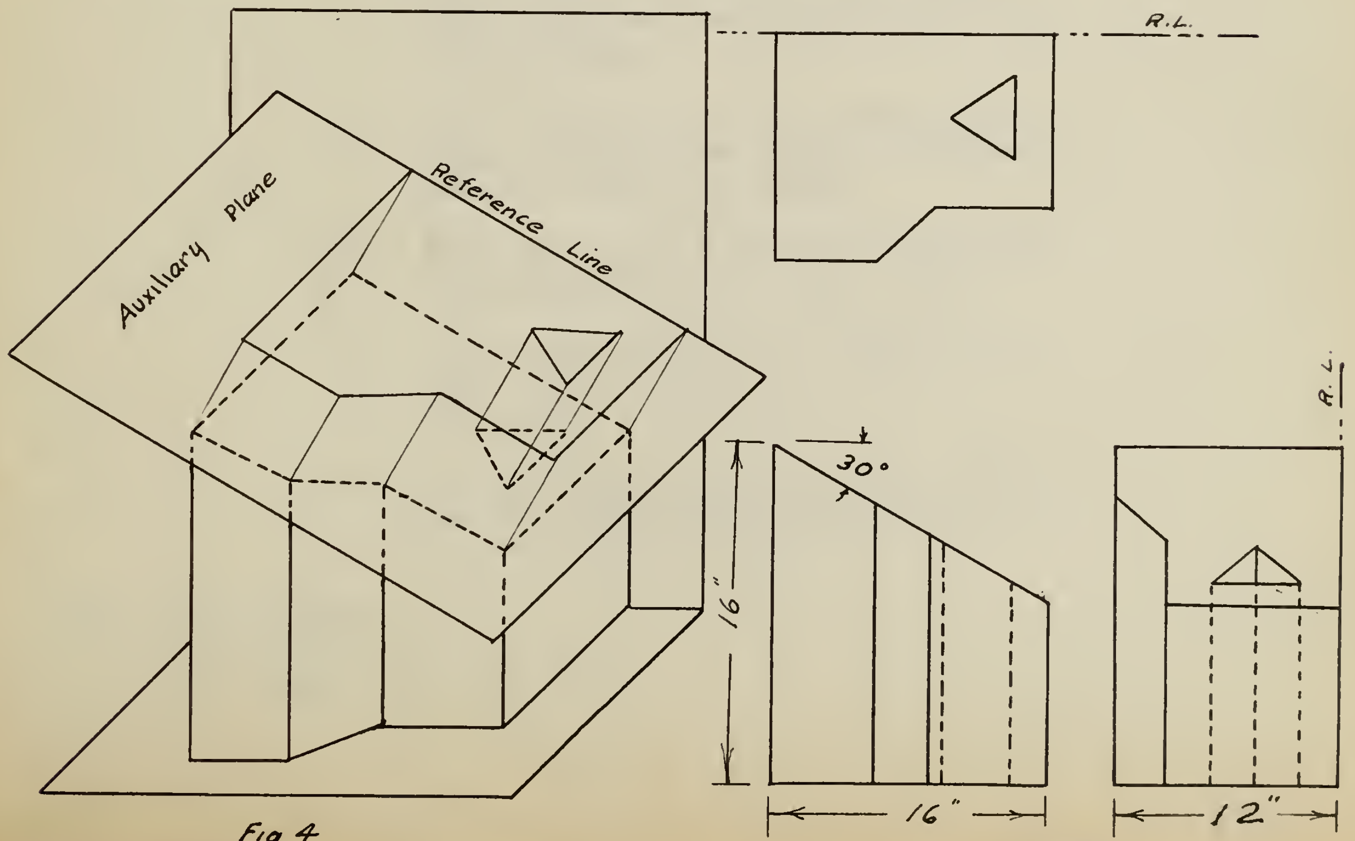


Fig 4

Fig 5

V Demonstration lecture:

1. Use of auxiliary views

   (a) A surface shows in its true shape when projected on a plane parallel to it.

      (a) In our first work we projected to the principle plane only.

      (b) In revolution we revolved with respect to the plane.

   (b) Instead of revolving the object we can now set up a plane parallel to the surface we want and project it on to it.

      (a) Give illustration from practice.

2. Solve the illustrative problem and bring out the following points:

   1. That two views or its equivalent must be given before an auxiliary view can be made.

   2. That a reference plane must be selected so that the auxiliary view will not interfere with the other views.

   3. That the width of the auxiliary view is the same as the width of the side and top views.

   4. That the length of the auxiliary view shows in the front view.

   5. Only that portion of the view is true size that is parallel to the slant surface.

   6. An auxiliary view of any surface can be made regardless whether it is true size or not.

VI Assignment:

Complete Plate 14.

PLATE 14

McGIVERY

Lesson 14 (Auxiliary View involving a curve)

I Reference--Same as for lesson 13,

II Aim:

1. To provide further practice in auxiliary views and solve problem involving curved surfaces.

2. To introduce the use of elements in the solution of problems having few edges.

III Specific abilities necessary to solve plate:

1. A good working knowledge of the principles of orthographic projection.

2. An understanding of the previous work on auxiliary views.

3. To be able to select cutting planes and obtain elements to secure the auxiliary view of a surface that is bounded by a curve.

IV Illustration problem for blackboard use:

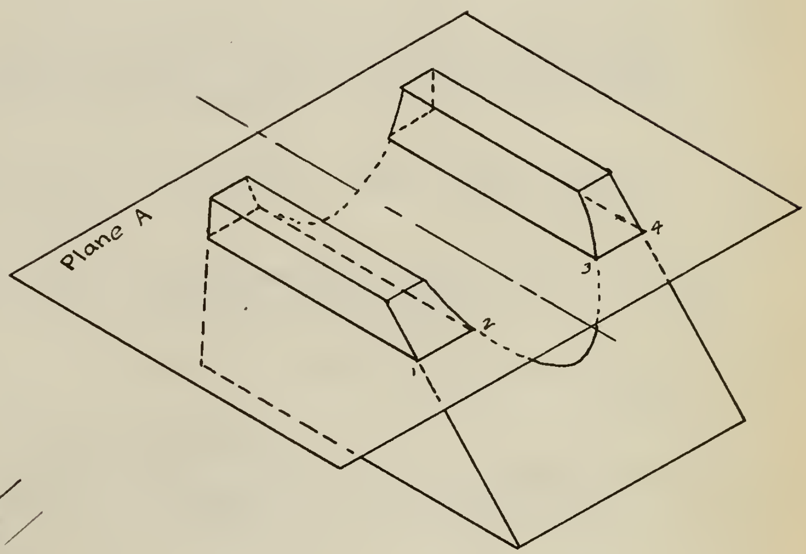


Fig 6

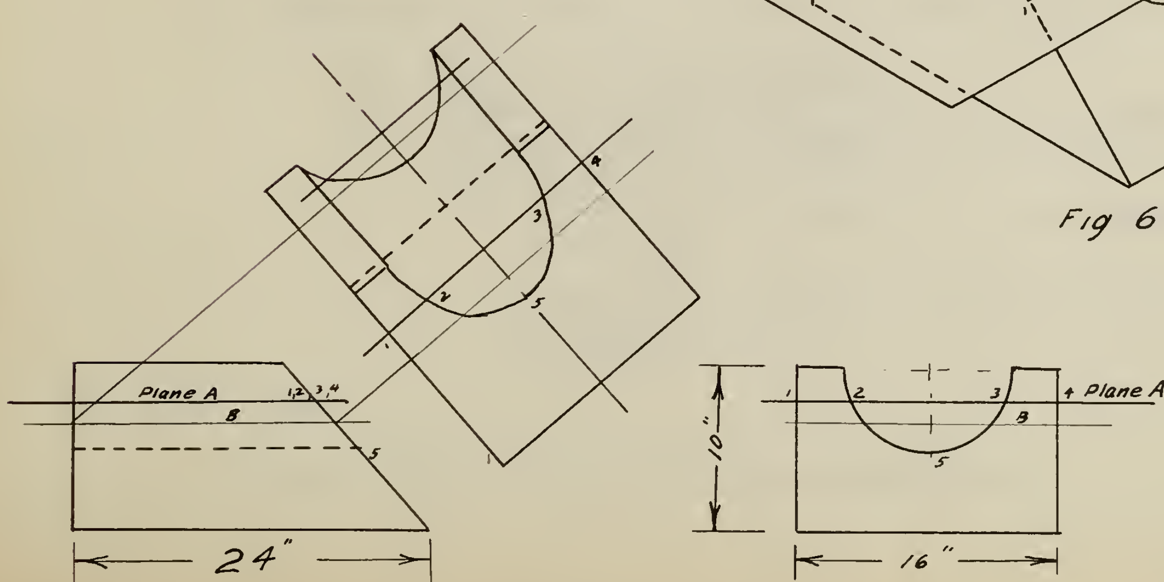


Fig 7

V Demonstration Lecture:

1. Limitations of our previous work in Auxiliary views.

   A. Not the easiest method for symmetrical objects.

   B. Does not lend itself to obtaining auxiliary views of volumes of revolution.

2. The value of the method of elements

3. Solving the illustrative problem:

   A. Draw the front and side views along with a free-hand pictorical illustration of the demonstration problem suggested while the class is laying out the front and side views of their plate.

   B. Speak of the use of a center line for obtaining auxiliary view of a symmetrical object.

   C. By means of the pictorical illustration illustrate the method of cutting plane and elements.

   D. Assume a cutting plane in the front view and obtain points on the curve as indicated under heading IV of this lesson.

   E. Speak of but do not locate these same points in the top view.

   F. Follow the same procedure for one more cutting plane and draw in curves free hand.

4. Speak on methods of review for mid-year examination:

   1. Review returned plates.
   2. Check over subjects listed on the outline.
   3. Solve free-hand problems in the text to save time.

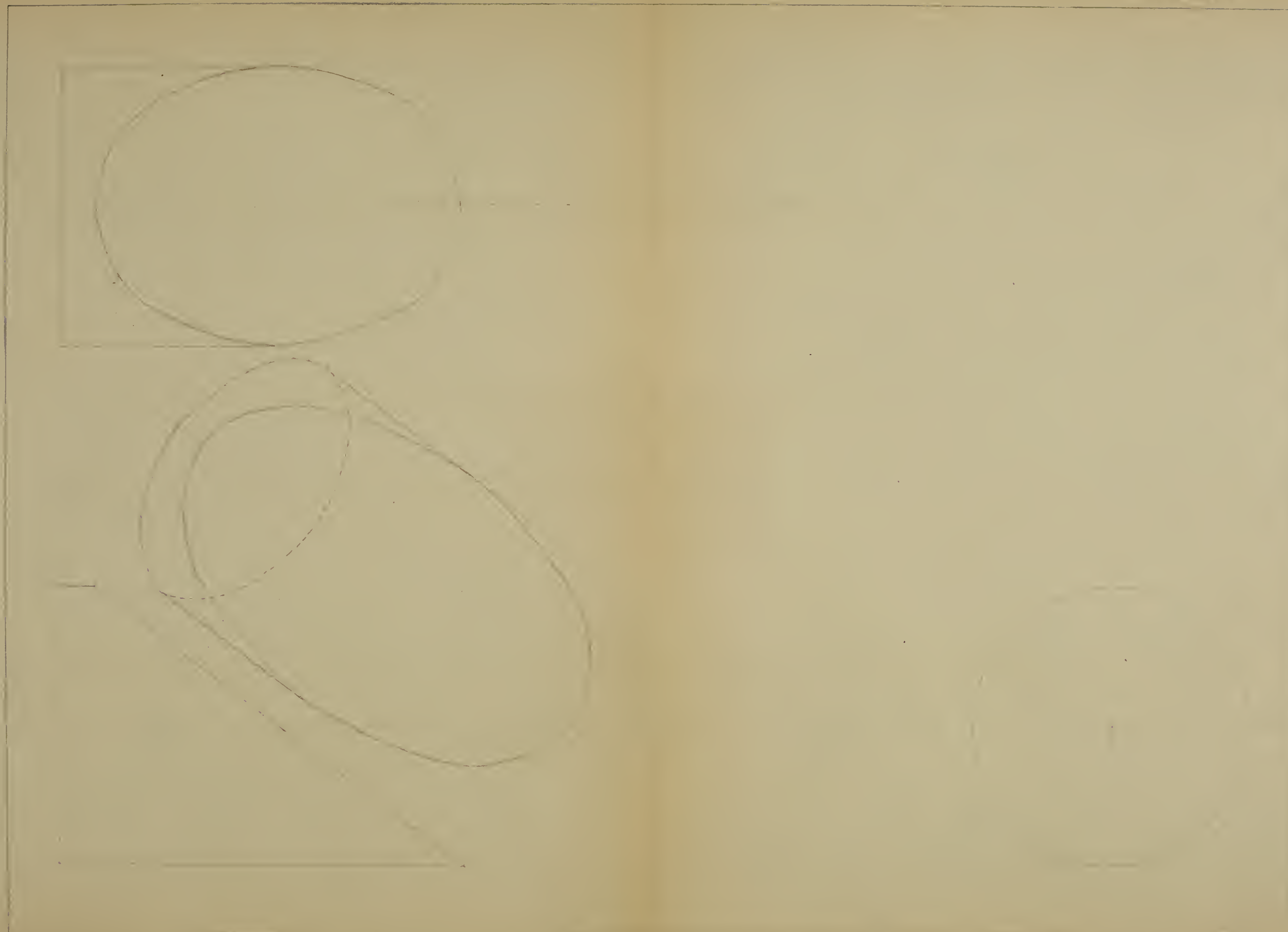
      (F) Page 108 &109 Draw in book missing view

      (F) Page 114 &115 Draw in free-hand auxiliary view.

VI Assignment

General review for mid-year examination.

PLATE



Lesson 16 (Conic Sections)

I References--(F) Page 66 Sec. 60 (S) Page 36 Sec. 83

II Aim:

1. To provide further practice in obtaining auxiliary views involving curved outlines.
2. To give graphical significance to the conic curves that are later to be studied analytically.
3. To define and illustrate terms that are fundamental for volumes of revolution.

III Specific abilities necessary to solve plate:

1. A working knowledge of the cutting plane method of obtaining auxiliary views.
2. A knowledge of relationship between the angle of the section plane and the conic curve obtained.

IV Illustration problem for blackboard use:

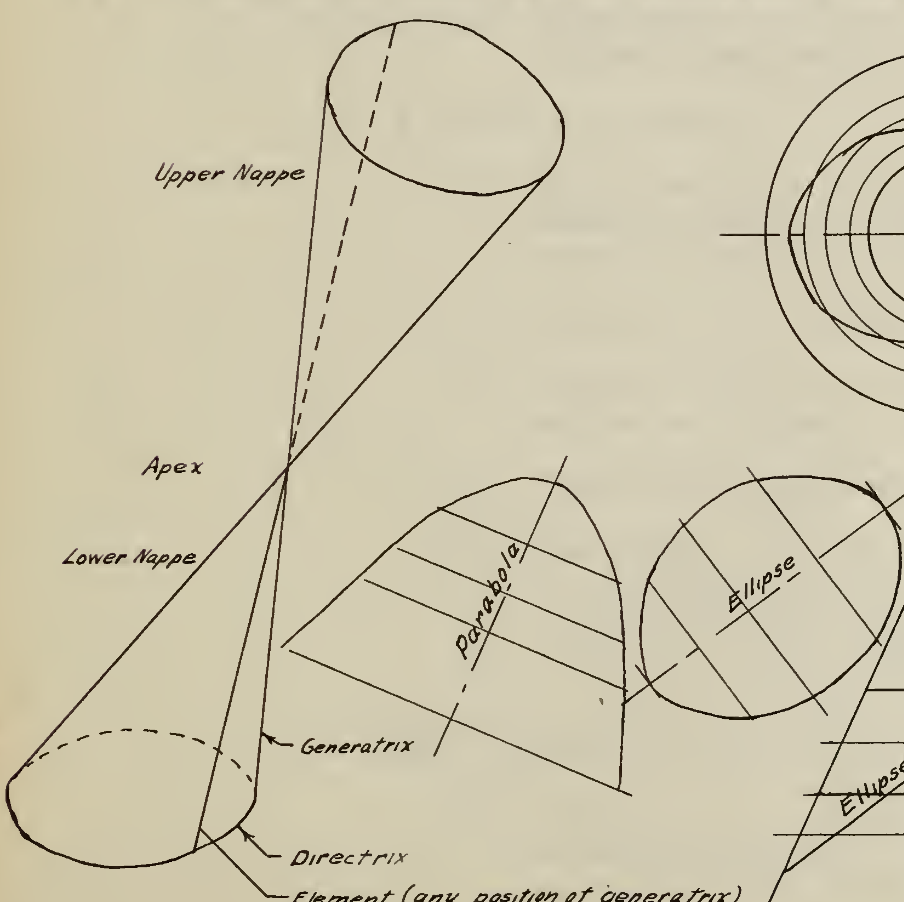


Fig 8

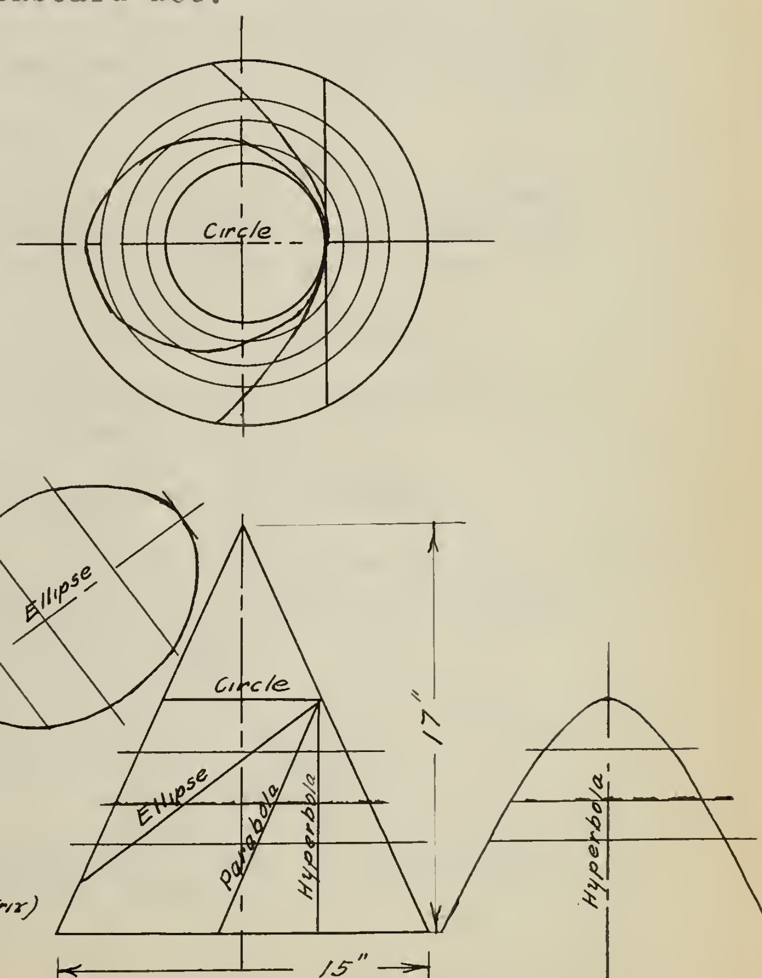


Fig 9

V Demonstration lecture

1. Historical importance of the conic sections.

   A The work of Apellaneous on "Conic Sections" is to this day considered as one of the great books in mathematics.

   B Practical importance of curves.

      Circle--one of the most common geometrical forms.

      Ellipse--Oblique view of circle, cams, gears.

      Parabola--curve of projectiles, reflectors, arches, uniformally loaded beam.

      Hyperbola--curve describing the expansion of steam with respect to pressure and volume.

2. Definitions (Illustrate by means of suggested sketch given under heading IV of this lesson)

   A A conical surface

      (a) Generated by a straight line constantly passing through a fixed point, one end moving along a closed plane curve.

      (b) Moving line is called a generatrix.

      (c) Any one position of the generatrix is called an element.

      (d) The curve is called the directrix.

      (e) The given point is called the apex. If the generatrix is infinite in length it generates two surfaces called the upper and lower nappes.

   B A cone is a solid bounded by a conical surface and a plane cutting all the elements.

      (a) If the base or cutting plane is a circle we have a circular cone, if an ellipse an ellipitical cone.

(b) The line from the apex to the mid point of the base is the axis.

(c) If the axis is perpendicular to the base we have a right cone, if oblique we have an oblique cone.

3. Conic sections may be derived from the right circular cone (Illustrate by free-hand sketch).

A The circle

(a) Cone cut by a plane perpendicular to the axis
(b) True size of curve in top view
(c) Infinite number of circles.

B The ellipse

(a) Cutting plane makes an angle with the axis greater than that which the element makes with the axis.

(b) Auxiliary view necessary to obtain true shape of curve.

C The parabola

(a) Cutting plane makes an angle with the axis equal to that which the element makes with the axis.

(b) Auxiliary view necessary to obtain true shape of curve

D The hyperbola

(a) Cutting plane makes an angle with the axis less than that the element makes with the axis.

(b) Auxiliary view necessary to obtain true shape of curve.

E Thought questions

(a) What are the limiting cases of the ellipse, parabola, and hyperbola?

(b) Could a parabola be a straight line?

(c) How many hyperbola are there?

4. Solve on blackboard the illustrative problem.

   A Use the convenient angles of 45° for the ellipse and vertical for the hyperbola.

   B Use horizontal auxiliary cutting planes.

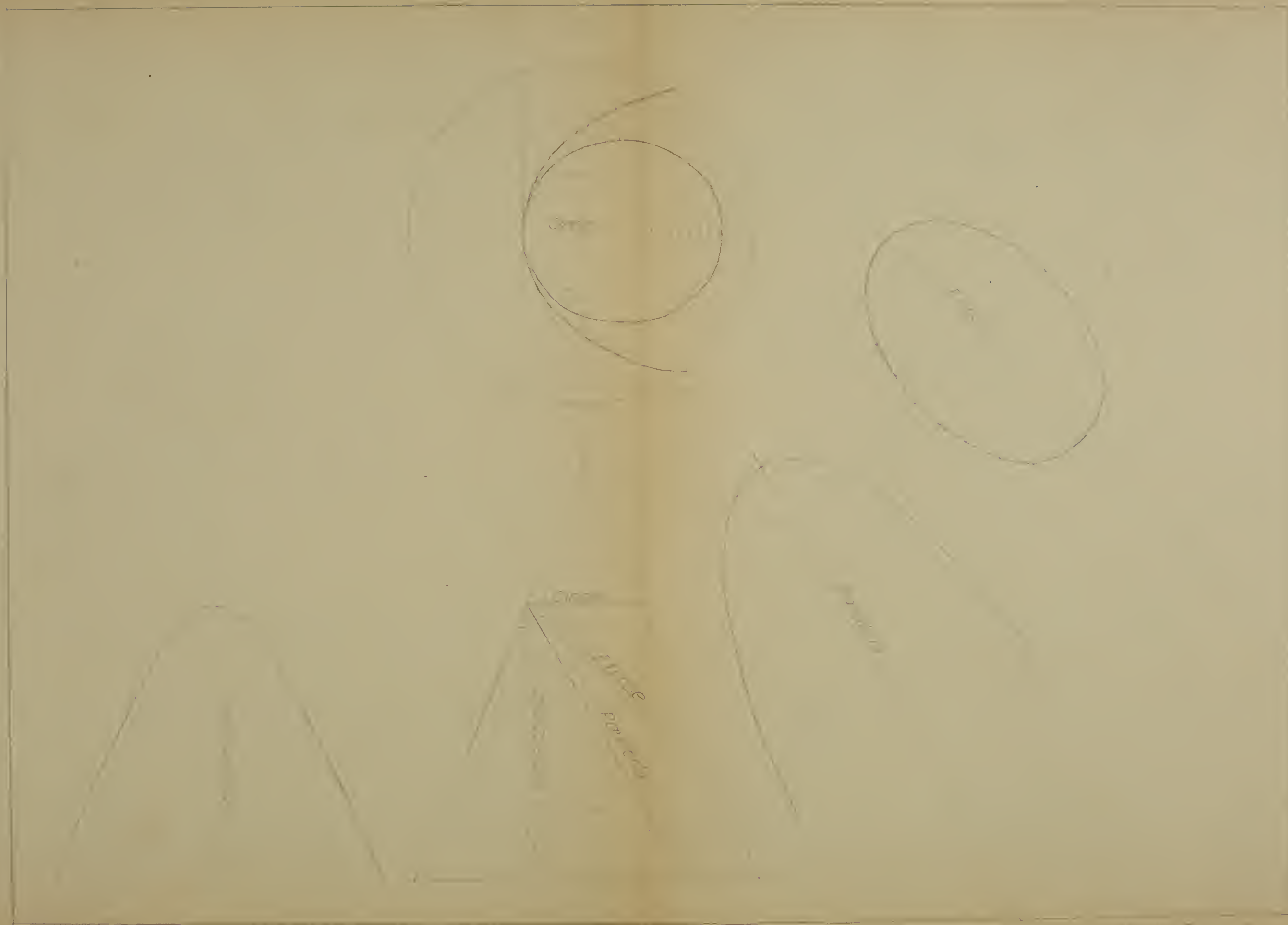
   C Obtain critical points and three others.

   D Draw in curves free hand.

VI Assignment

1 Complete Plate 16

2 Study (F) Arts 61, 62, 63, 65, 70 and 74.



Lesson 17 (Conic Curves)

I References--(F) PP 67-76 (S) PP 37-40

Special Reference--Any standard text on Analytic Geometry.

II Aim:

1. To give practical graphical method for drawing the conic curves without reference to the right circular cone.

2. To show the relation between the graphical and analytical solutions.

III Abilities necessary to solve plate

1. To know and be able to apply the definitions of the conic curves together with their common properties.

IV Illustrations for blackboard use:

When defining the terms it is well to make a free-hand drawing of the curve to illustrate the terms used and their meanings. Using the definitions method of drawing an ellipse illustrate how from the definitions alone enough information is at hand to draw the curve. Locate the foci of the ellipse and obtain a few points on the curve. Draw a tangent at some point on the curve. Show the similarity between the hyperbola and the ellipse in method of plotting and illustrate by locating a few points on a curve. Do not draw a parabola but allow the students work it out for themselves by referring to the definition and the text.

V Demonstration lecture

1. Definitions

A Circle is a curve generated by a point moving in a plane such that its distance from a fixed point is a constant.

(a) Show that it agrees with equation of circle $x^2+y^2=r^2$

B Ellipse is a curve generated by a point moving in a plane such that the sum of its distance from two fixed points is a constant.

(a) Sum of a distance equals the major axis
(b) How to locate the foci when the major and minor axis are given.

(c) The tangent to an ellipse

(d) Conjugate diameters

(e) Show its similarity to the circle

(f) Equation $\frac{x^2}{a^2} + \frac{y^2}{b^2} = C$

C Hyperbola is a curve generated by a point moving in a plane such that the difference of its distances from two fixed points is a constant.

(a) Differences of its distances equals the axis.

(b) Its relation to the circle and ellipse.

(1) circle $x^2 + y^2 = r$

(2) ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = C$

(3) hyperbola $\frac{x^2}{a^2} - \frac{y^2}{b^2} = C$

(c) Always two branches to the curve.

A Equation can show this as well as graphical construction involving upper and lower napes.

D Parabola is a curve generated by a point moving in a plane such that its distance from a fixed point equals its distance from a fixed line.

(a) Vertex, half way between focus and directrix.

(b) Illustrate by free-hand sketch only.

E Trammel method of drawing an ellipse.

(a) Teach this as a drill procedure.

VI Assignment

1 Complete Plate 17
2 Study (F) Arts 95 to 101 (inclusive)

Ellipse Definition Method

Ellipse [illegible] Method

Parabola Definition Method

Hyperbola - Definition Method

Lesson 18 (Sections)

I References (F) pp 98-102 (S) pp 59-63

II Aim:

1. To learn to make and read simple section drawings and acquire the meaning of the cross section symbols.

III Abilities necessary to solve plate:

1. The ability to visualize an imaginary cutting plane through an object.

2. To be able to locate a section plane to show the interior of an object to best advantage.

3. To know and be able to apply the cross section symbols.

4. To understand the principles of sectioning.

IV Illustrated lecture:

1. Use of the section view

A It is a special form of auxiliary view

B Used to define the object more clearly than the external view can do when the full line constructions tend to confuse the hidden shape or parts.

2. Method of presentation.

The textbook offers many good illustrations of sectioning so that this lesson affords an opportunity to teach the students the value of, and how to study, the textbook. The principles to be covered can be taught by this method alone. The following is a suggested procedure that will produce the desired outcomes.

A pp 98-101 Fundamental material with emphasis on the five principles in sectioning on page 99. Refer to page 448 for symbols for material.

Fig. 190 Page 98 illustrates the first principle.
Fig. 191 Page 98 Fig. 459 Page 209 and Fig. 539 Page 265 illustrates second principle.
Fig. 537 Page 263 and Fig. 544 Page 267 illustrates third principle.
Fig. 527 Page 257 and Fig. 559 Page 282 illustrates fourth principle.
Fig. 539 Page 265 and Fig. 563 Page 287 illustrates fifth principle.

B Violations of theory for sake of speed and clearness (idioms of the graphic language)

(a) Symmetrical and not symmetrical objects sectioned Fig. 473 and 474 page 222.

(b) Ribs in section Fig. 476 page 224

(c) Holes in section Fig. 477 and 278 pp 224 and 225.

(d) Revolved section Fig. 481 page 226 and Fig. 514 page 250.

C Phantom Sections

Fig. 193 Page 100

D Broken sections

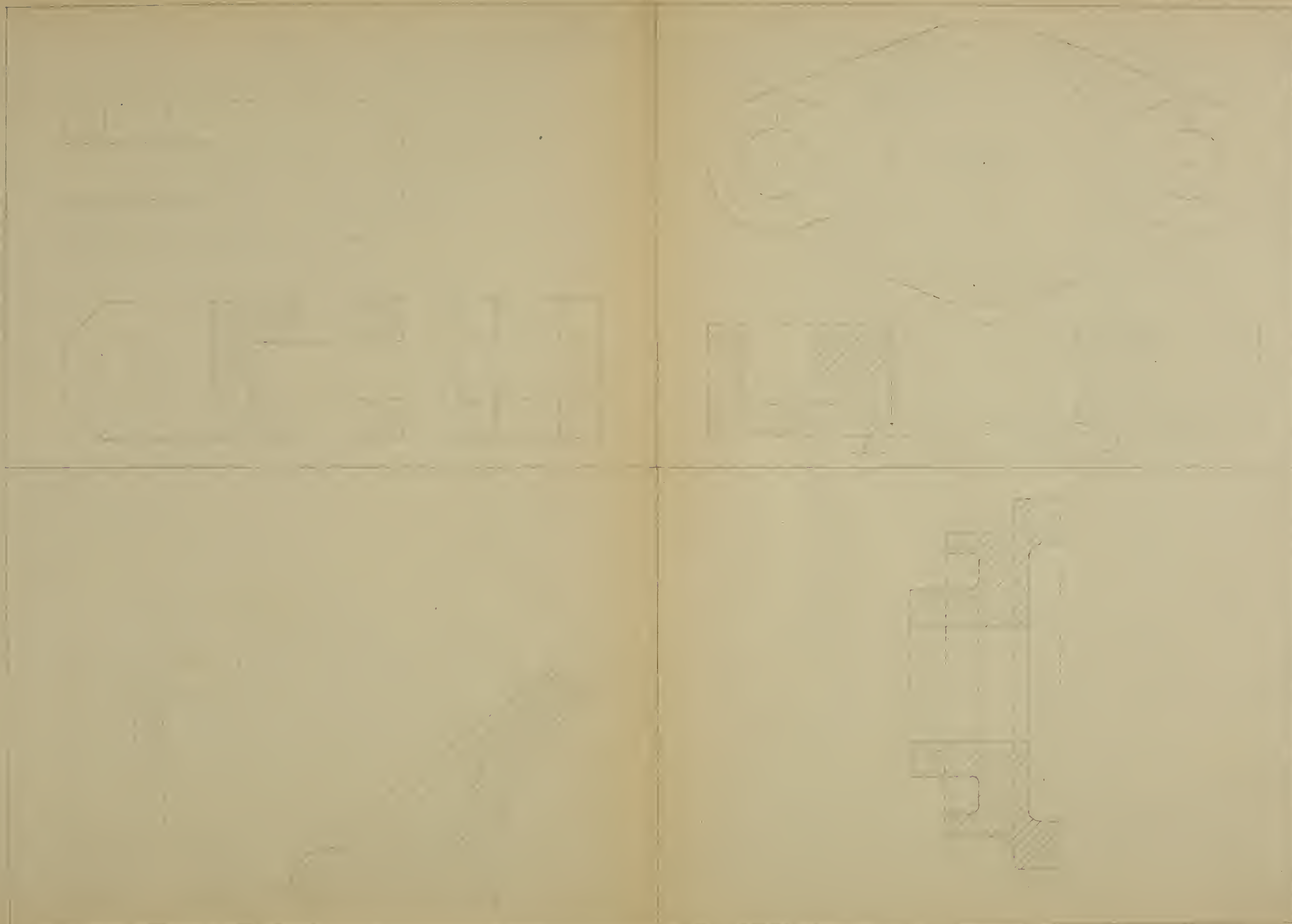
Fig. 529 Page 158 and Fig. 517 Page 251.

E Techniques of sectioning.

Spacing is done entirely by eye.
Large pieces sectioned only at edges.
Different materials have different symbols.
Section line ——————— — ——————— — —————

V Assignment

Complete Plate 18.



Lesson 19 (Sections)

I References (F) pp 98-102 (S) pp 59-60

Special reference: Svensen G. L. "Machine Drawing" pp 38-58 D. Van Nostrand Co. New York 1928.

II Aim:

1. To provide further training in making section drawings.
2. To teach the students to be able to read detail drawings.

III Specific abilities necessary to solve plate.

1. Ability to make and read section drawings and to know the conventional practices employed in sectioning.

2. The ability to read detail drawings.

3. A knowledge of a conventional method of representing screw threads.

IV Illustration for blackboard use:

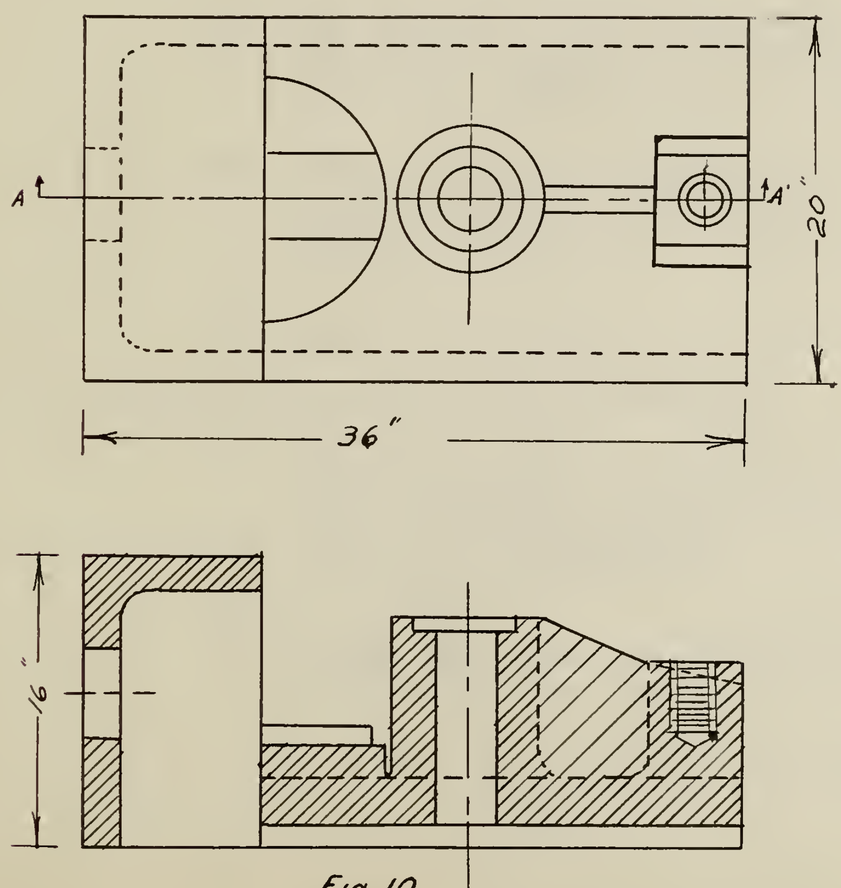


Fig 10

V Demonstration lecture

1. Function of a jig.

2. The purpose of detail drawings.

   A. The relation of the details to the assembly.

3. Errors and omissions in the detail of jig base and how they are rectified or supplied.

   A. Diameter of large circle in side view is missing.

      (a) It is $3\frac{3}{4}$" in diameter as found from size of detail of cold rolled steel plates.

   B. 1-27/32" dimension should extend from top of boss to the base of the piece instead of $\frac{1}{2}$" from the base.

      (a) Obtained by adding the dimensions.

   C. The width of the slant surface containing the 9/16" tapped hole is 1-5/8" wide and should be shown in the top view.

   D. Many lines are omitted in the top view for the sake of clearness but can be easily supplied upon inspection of the other two views.

   E. Speak of locating the views on the plate.

4. Solving the demonstration problem.

   A. While the class is laying out their plate draw, full view, top, and front views of the problem, suggested, under heading IV, on the blackboard.

   B. In solving the problem before the class the above principles for which the problem was designed, should be stressed.

      1. That the section plane should pass through the center of the object.

      2. That the visibility of many of the lines change in the section view.

3. That only those surfaces which touch the section plane are sectioned.

4. That the accepted conventional method for sectioning the web is to extend every other section line.

5. That the same piece is always crosshatched in the same direction and spacing regardless of where it appears.

   (a) The left-hand end illustrates this principle.

6. That true projection is preferable when it does not involve toogreat a loss of time.

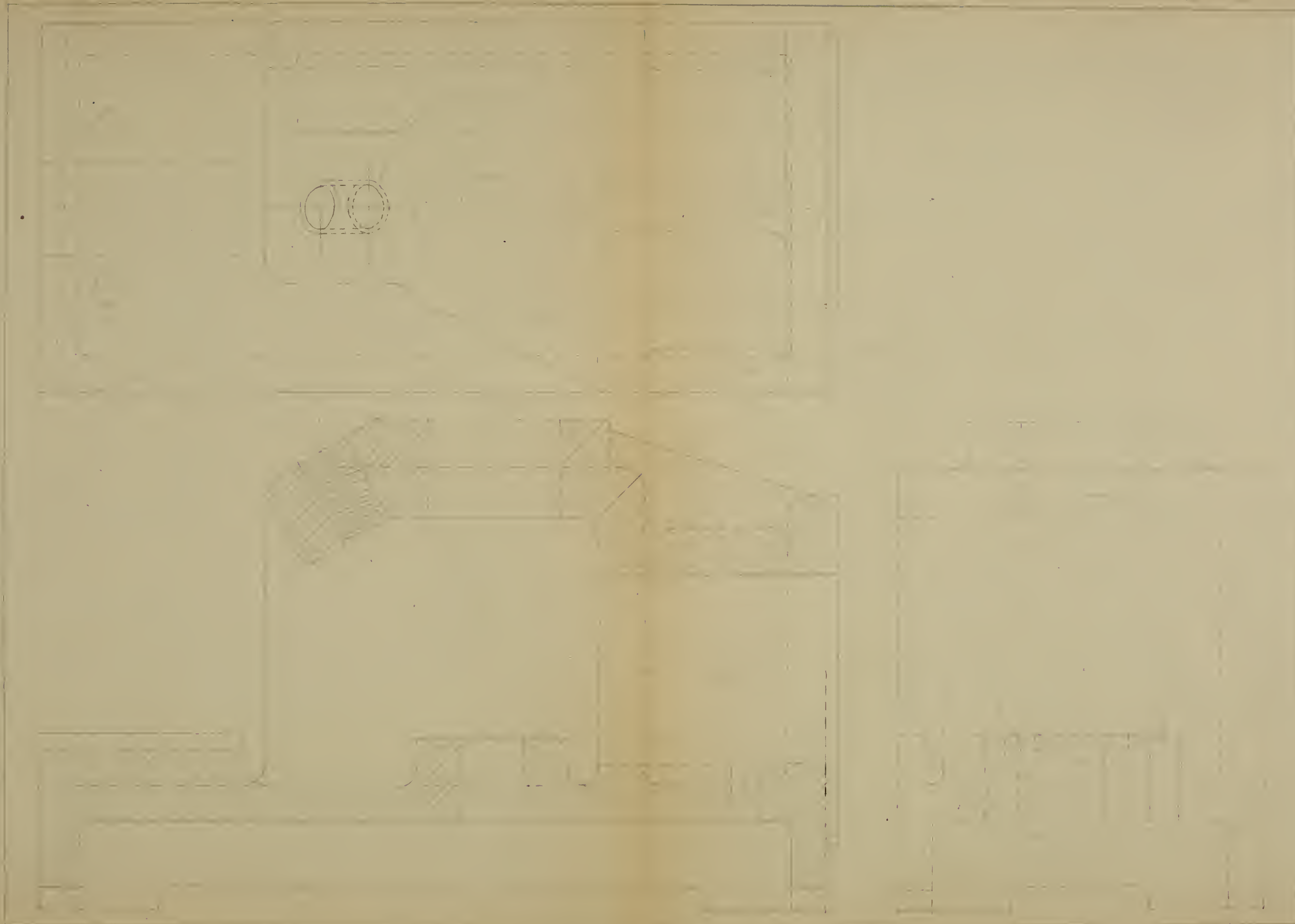
7. That in this case dotted lines defining edges behind the section plane are necessary for a complete description of the piece.

8. That a straight line convention may be used to represent a tapped hole.

VI Assignment

1. Complete Plate 19.

2. Study (F) Arts 135 and 136.



Lesson 20 (Intersection and development of prisims)

I References (F) pp 148-170 (S) pp 130-158

II Aim:

1. To teach a method of finding the intersection between two prisms..

2. To teach how to determine the visibility of a curve or curves of intersection between two prisms.

3. To give conditions from which to obtain and to develope the surfaces of the intersected prisms.

III Specific abilities necessary to solve plate.

1. A through knowledge of the previously taught principles of orthographic projection.

2. To be able to determine the point of piercing of a line in a plane.

   A When it can be determined directly from one of the views.

   B When an auxiliary line or plane is necessary.

3. To be able to determine the visibility of a curve of intersection.

4. To be able to recognize the true length of a line.

5. To be able to develope a prism with the cut or cuts necessary for the intersecting prism.

IV Illustrative problem for blackboard use:

(drawing on next page)

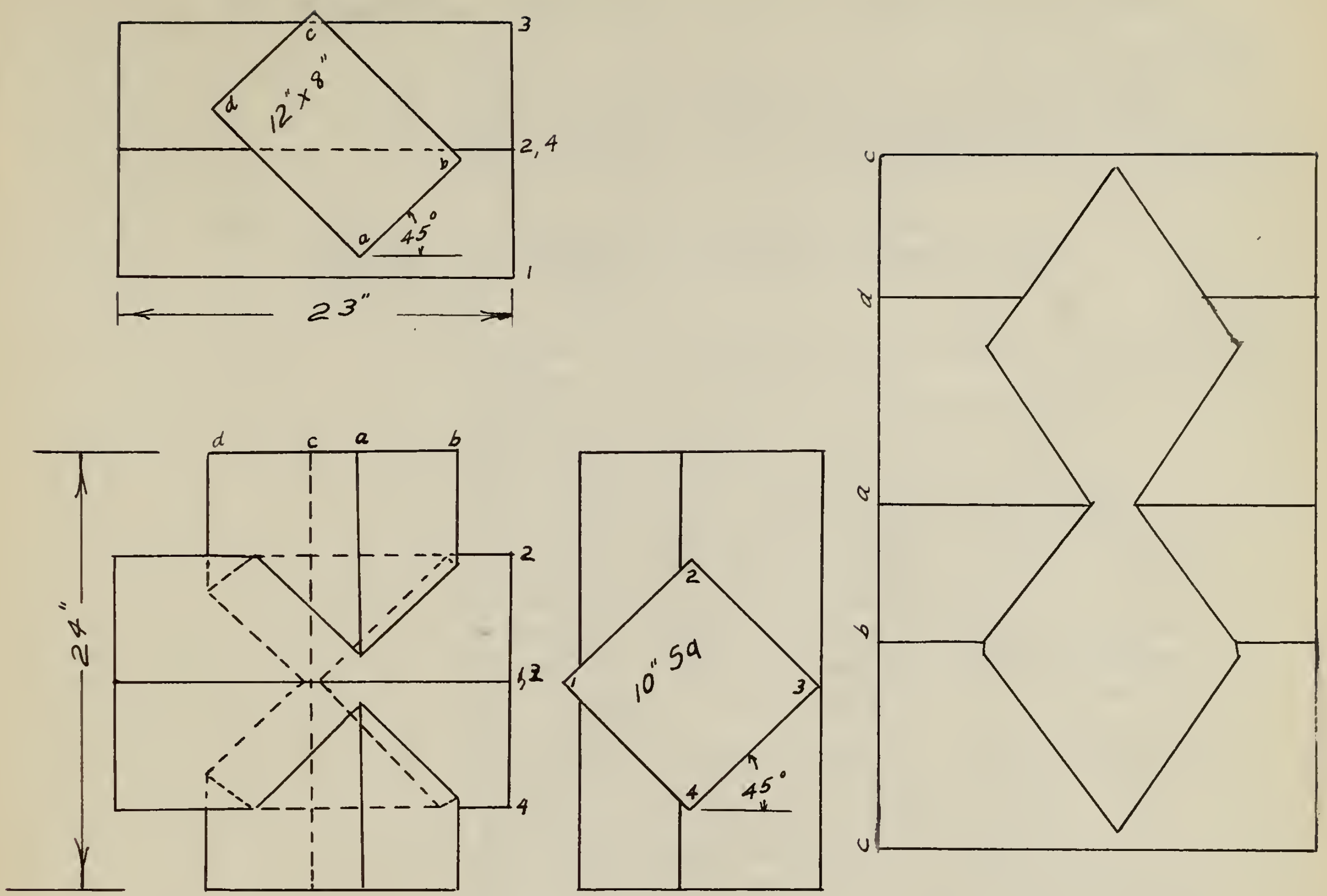


Fig 11

V Demonstration lecture.

1. What we already know.

   A. How to represent by three views the size and shape of an object.

   B. How to represent the inside of an object by a section view.

   C. How to represent the true size of a part of an object by means of an auxiliary view.

2. What we want to know.

   A. How to represent the size and shape resulting from the combination of two or more objects.

   B. How to determine the true shape of the development of a complete object.

3. Suggested questions on the preceding assignment.

   A. What is the intersection between two lines?
   B. What is the intersection of two lines?
   C. What shape is the development of a cylinder?
   D. What shape is the development of a cone?

4. Solving the demonstration problem.
   (Assume the square prism goes through the rectangular one.)

   A. Number the lines of the square horizontal prism.
   B. Letter the lines of the rectangular vertical prism.
   C. What lines do not intersect either cylinders (are they full or dotted)
   D. What view shows directly the points of intersection of the lines of the square prism into the rectangular one.
   E. When the answer to the above is understood by all project from the top view the points of intersection for lines 2, 3 and 4.
   F. What view shows directly the points of intersection of the lines of the vertical prism into the horizontal.
   G. When the above answer is understood project from the side view to the front obtaining the points of intersection for lines a, b, and d.
   H. By following around the curve in the top and side views connect the points in the front view and explain visibility.
   I. Speak of development and complete the development of the four sides, top and base of the rectangular prism.
   J. Locate points of the intersection of lines a, b, and d.
   K. Locate points within the spaces and connect points.

VI Assignment

Complete Plate 20.

M[illegible]ERN J. [illegible]

Lesson 21 (Intersection of prisms)

I References--(F) pp 148-170 (S) pp 130-158

II Aim:

1. To provide further training in intersection of prisms and to introduce the auxiliary line as one part of the method of solution.

III Specific abilities necessary to solve plate:

1. An understanding of the work of the preceding lesson.

2. To know how and when to select auxiliary lines for determining the points of piercing of lines in planes.

IV Illustration for blackboard use:

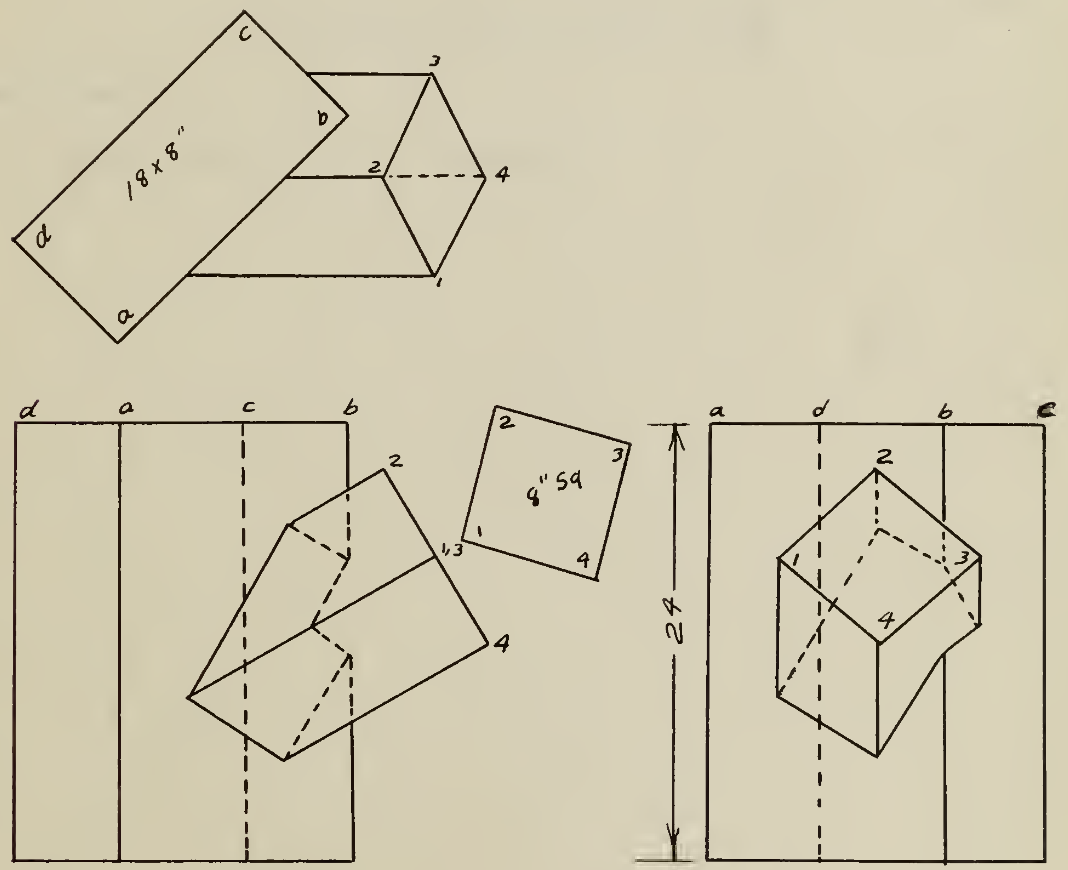


Fig 12

V Demonstration lecture.

1. While the class is laying out this plate draw on the board a complete top view and the front view complete but for the intersection.

2. The work of this lecture can be completed in about twenty minutes as the foundation was laid in the previous lesson.

3. Review the principles of last lesson and teach the following new points.

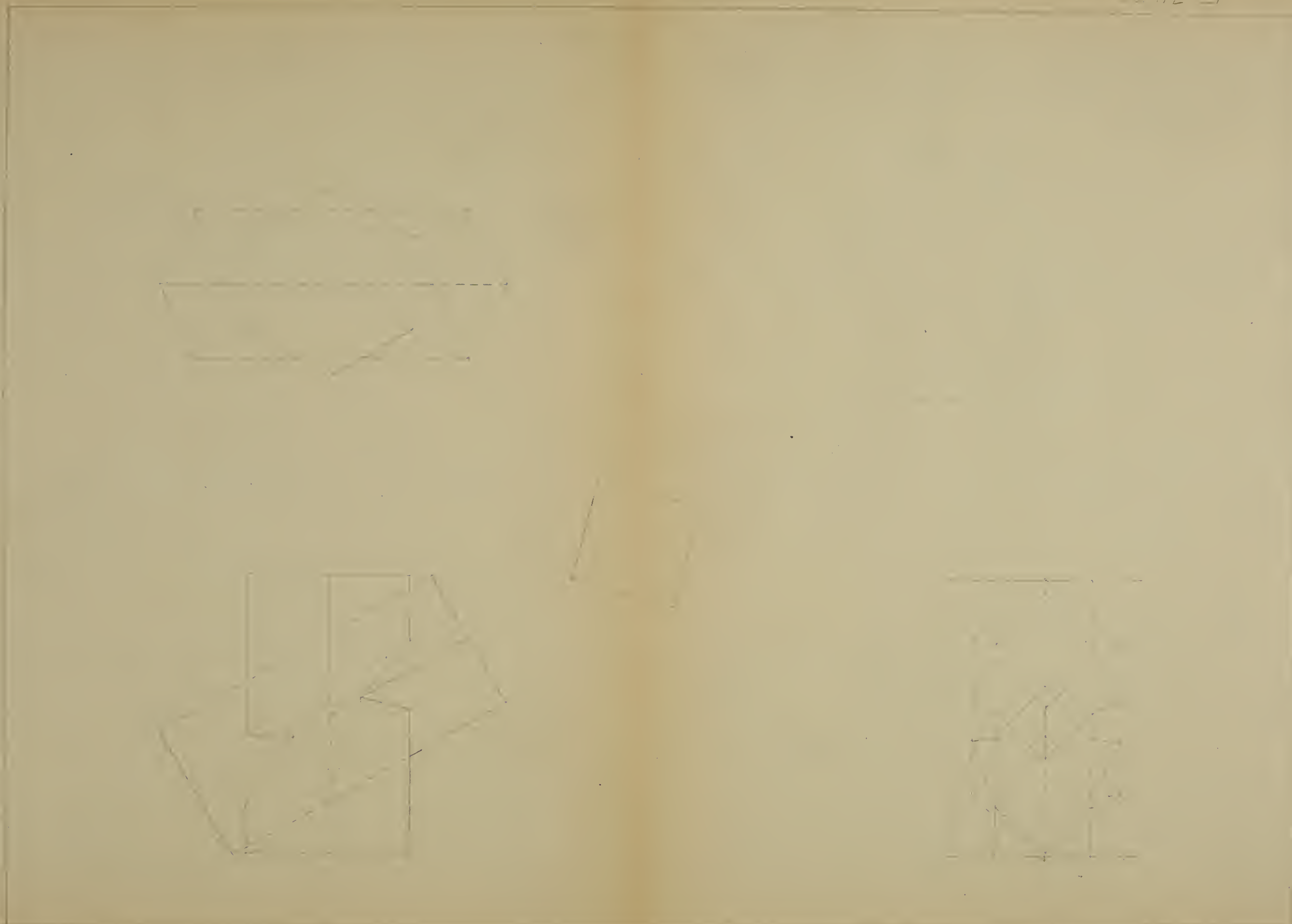
    A. By means of auxiliary lines on surfaces 2,3 and 1, 2 determine the points of piercing of line "b".

    B. Complete the intersection of the side view from the front view.

VI Assignment

I. Study (F) Arts 137 and 138.

PLATE 21



Lesson 22 (Intersection of cylinders)

I References (F) pp 160-164 (S)

Special Reference--Anthony G. C. and Ashly G. F. "Descriptive Geometry" pp 121-130. Boston D. C. Heath 2nd Edition 1926.

II Aim:

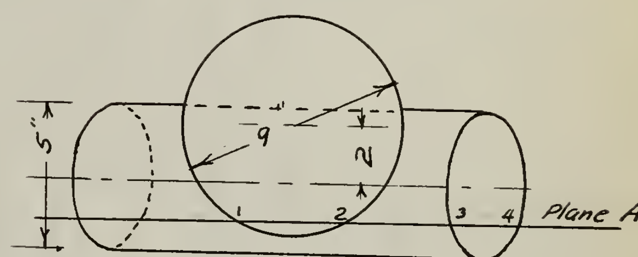
1. To teach a method for determining the intersection between two cylinders.

III Specific abilities necessary for solving class plate:

1. A working knowledge of the methods of auxiliary sections for finding the intersection between two cylinders.

IV Illustration for blackboard use.

Shade in instead of crosshatching



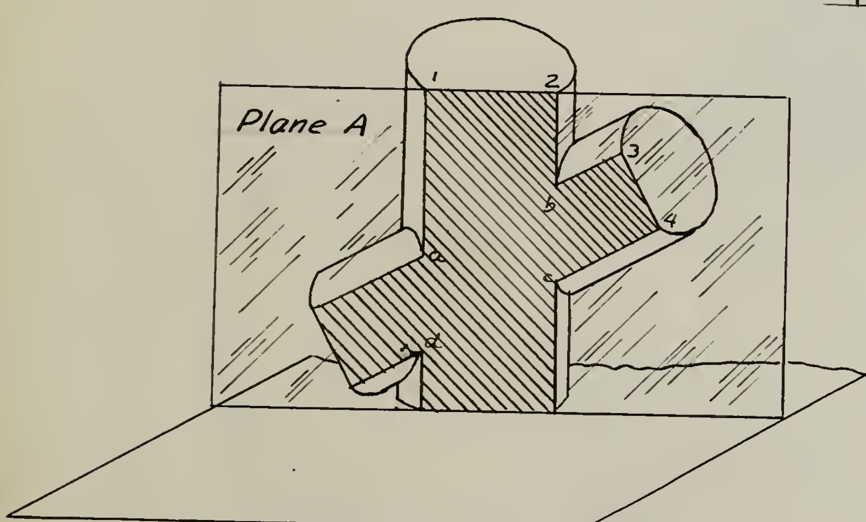


Fig 13

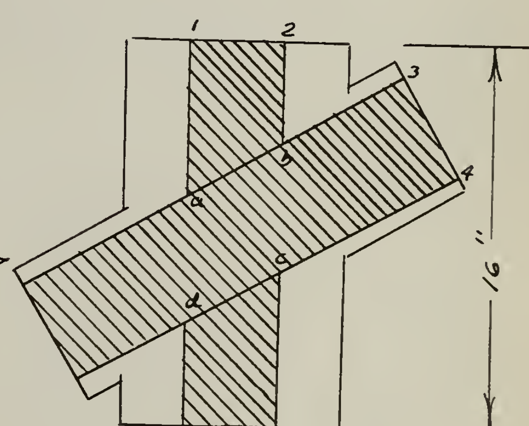


Fig 14

V Illustrated lecture:

1. Limitations of our previous work on intersection.

   A. Applied only to solids having edges.

2. An auxiliary section may be thought of as a method of manufacturing edges.

3. Determining intersection of critical elements.

4. Explain the auxiliary section by referring to the pictorical sketch.

5. Locate a few points on the curve of intersection.

6. Explain the use of the french curve in drawing in curve.

VI. Review for two hour examination for next class.

A. Fundamentals of cone and conic sections.

B. Conic curves.

C. Solve free hand some of the problems on pages 167, 168, 169 for practice on intersection.

   (a) Draw the lines right in the figures in the text to save the time of laying out the problem.

VII Assignment

Review for two-hour examination.

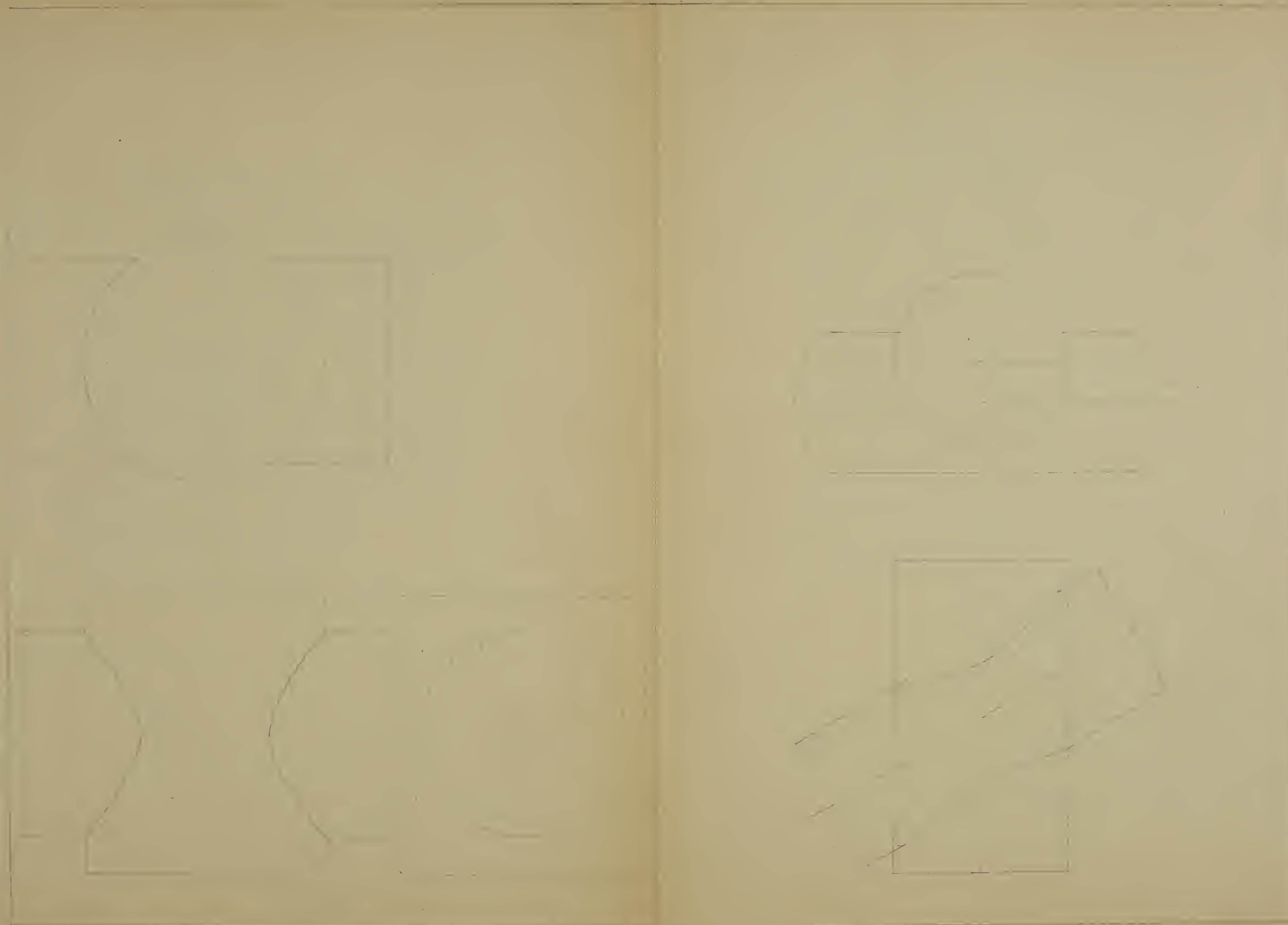
Lesson 23

I Two-hour examination.

II Assignment

1. Study (F) Arts 125 to 130 (inclusive)

PLATE



Lesson 24 (True length and development)

I References (F) Art 129 p 152 (S) pp 145-151

II Aim:

1. To extend the knowledge of development to include problems involving the true lengths of lines.

2. To co-ordinate the work of development, true length, auxiliary view and simple intersection in one problem.

III Abilities necessary to solve problem:

1. To be able to obtain the true length of a line by revolving it parallel to the vertical plane.

2. To be able to develope the surface of a truncated pyramid.

3. To be able to draw an auxiliary view.

4. To be able to transfer a figure.

IV Illustration for blackboard use:

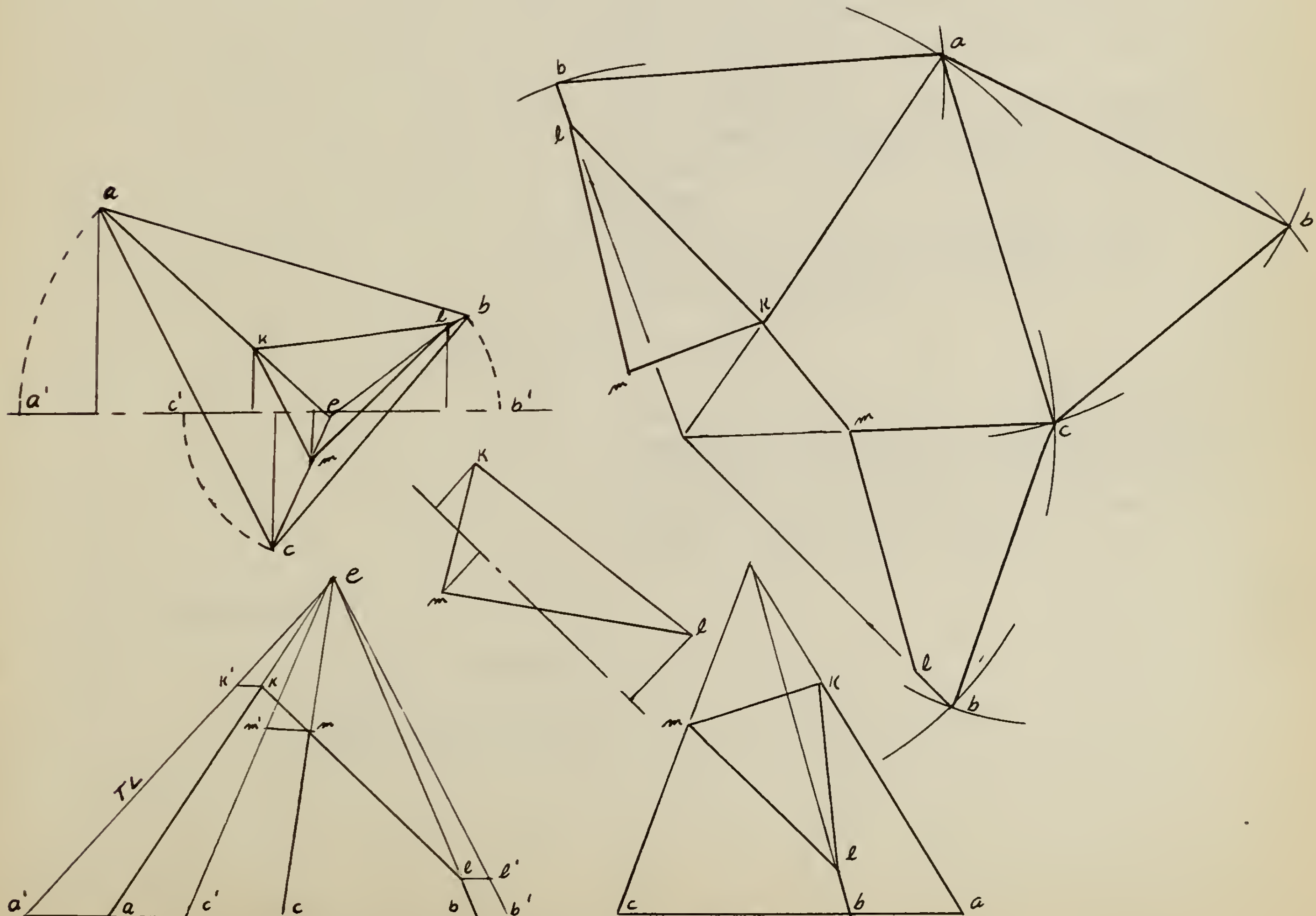


Fig 15 (For blackboard - use scale 8" = 1"

V Demonstration lecture:

1. The type of problems covered this far in the study of development.

2. The new work to be covered and the new principle involved.

3. Using the pointer, or compass, as an isolated line in space revolve it to a position parallel to the vertical plane.

   A. In revolving the line the true length showed in the vertical or front view.

   B. The true distance from one end to any other point on the line also become apparent.

4. Solve the demonstration problem.

   A. Analyze the problem with the class by questioning and recitation.

      (a) The true length of the long edges must be solved.
      (b) The base appears in true size in the top view.
      (c) The development will be a series of three triangles with a triangular base and slant surfaces added.
      (d) The true size of the slant surface may be obtained from an auxiliary view.

   B. Solve the problem.

      (a) When completing the development transfer the slant surface from the auxiliary view and use the corresponding lines in the auxiliary view as a check.

IV Assignment

1. Complete Plate 23

2. Study (F) Arts 104 to 113 (inclusive)

Lesson 25 (Isometric Drawing)

I References (F) pp 122-147 (S) pp 159-172

II Aim:

1. To teach the fundamental principles of isometric drawing as applied to objects not having any curved surfaces.

2. To provide an exercise for reading orthographic projections.

III Specific abilities necessary to solve plate:

1. A good reading knowledge of orthographic projection.
2. Working knowledge of the fundamental principles of isometric drawing including the following principles.

   A. True measurements can be made only on isometric lines.
   B. The method of box construction.
   C. The method of offset.

IV Illustration for blackboard use:

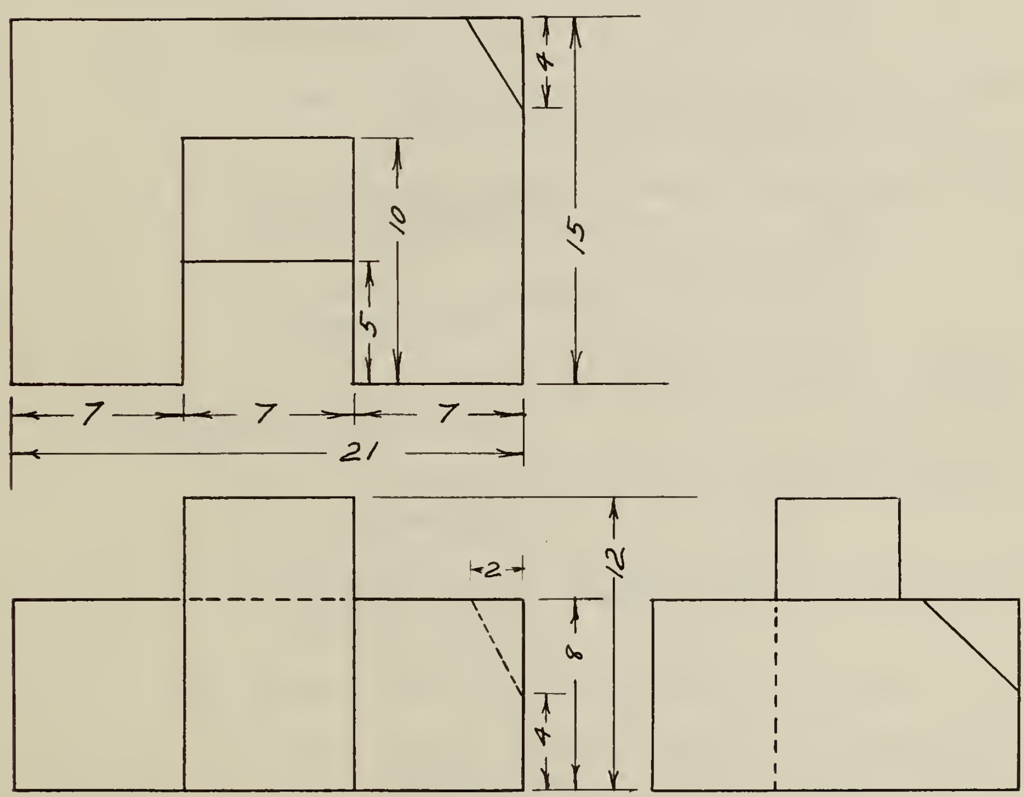


Fig 16

V Demonstration lecture

1. Difference between orthographic perspective and isometric.

    A. Orthographic.

        (a) Gives actual shape and size.
        (b) Requires geometric imagination.
        (c) Requires three views.

    B. Perspective.

        (a) Gives an effect pleasing to the eye.
        (b) Not easy to make.
        (c) Its lines cannot be measured.

    C. Isometric.

        (a) Combination of pictorical effect of perspective and possibility of measuring lines directly.

2. Theory of isometric projection

    A. Refer to (F) page 123 Fig. 258

        (a) Explain the figure by refering to the principles of revolution.

    B. Difference between isometric projection and isometric drawing.

    C. Isometric a special condition of orthographic.

3. Solve the demonstration problem illustrating the following principles.

    A. The isometric axises are vertical and 30° lines only.

    B. Isometric line is any line parallel to an isometric axis.

    C. How to make an isometric drawing.

        (a) Start with a point representing the front corner or the edges extended.
        (b) From this point draw the three isometric axises.

(c) Measure length, width and thickness on these lines through the measurement points parallel to the axises.

D. Measurements can be made only on isometric lines.

E. Non-isometric lines do not appear in true length.

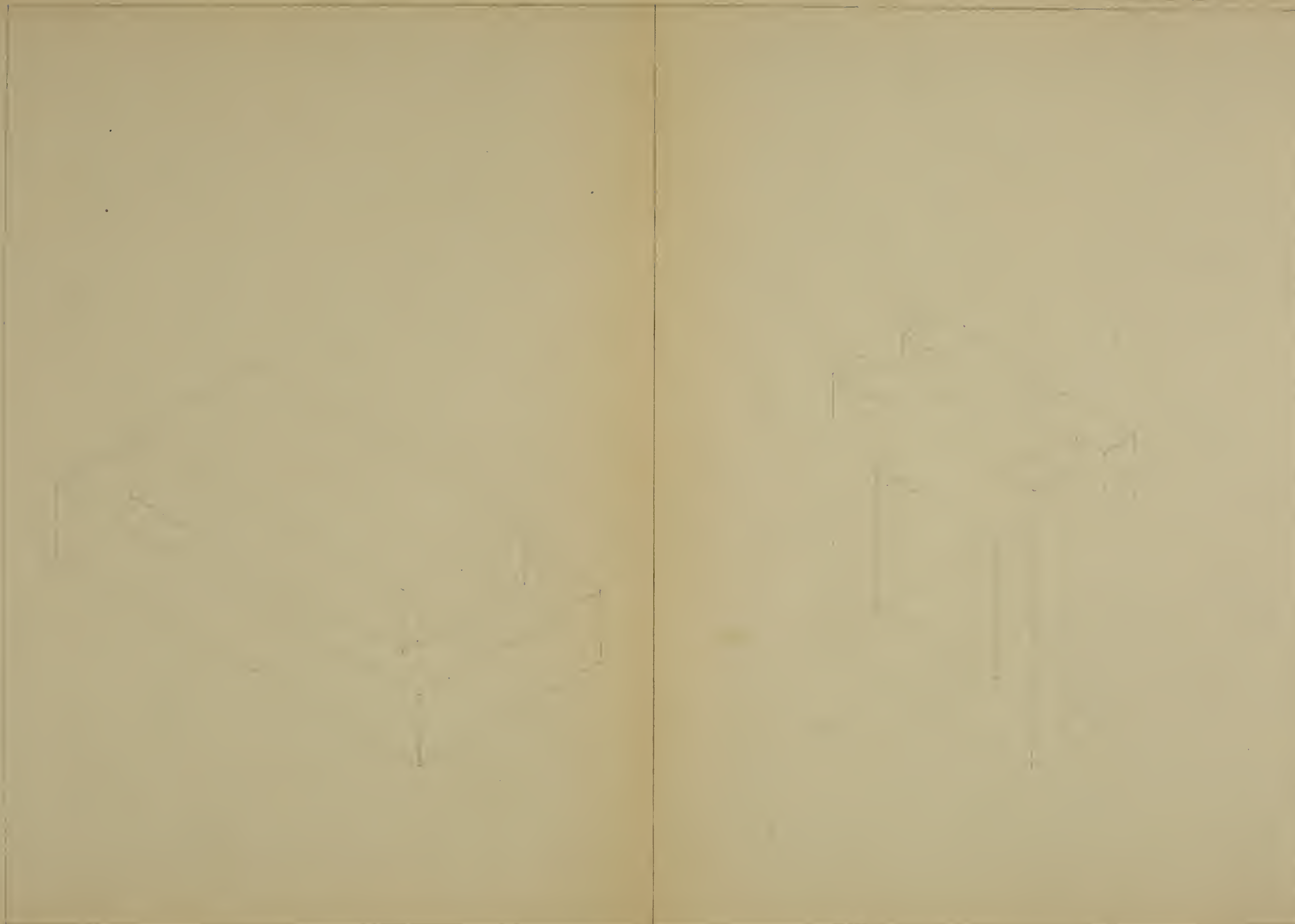
F. Lines which are parallel on the object will appear parallel in isometric.

G. Non-isometric lines must be co-ordinated.

H. The offset method for plotting non-isometric lines.

VI Assignment

1. Restudy (F) Arts 104 to 113 (inclusive)



Lesson 26 (Curvilinear isometric)

I References (F) pp 122-147 (S) pp 159-172

II Aim:

1. To provide further training in isometric drawing and extend the subject to include the drawing of objects having curved as well as plane surfaces.

III Specific abilities necessary to solve the plate:

1. A good reading knowledge of orthographic projection.

2. The ability to block in an object in isometric.

3. To be able to use the offset method.

4. To know and be able to apply the four center approximate method of drawing a circle or semi-circle in isometric.

IV Illustrative problem for blackboard use:

1. Draw, in isometric, a cube 15" on a side and draw by means of the four point approximates method an ellipse on each of the three visible surfaces.

2. Draw in isometric a semi-circular cylinder 15" in diameter and 24" long to illustrate how to draw a semi-circle in isometric and how to transfer centers without redrawing the complete constructions when circles appear on parallel surfaces.

V Demonstration lecture:

1. The work of this lecture is concerned entirely with solving the demonstration problem by means of which the abilities listed under heading III are either reviewed or learned. In teaching the approximate method of drawing an ellipse it should be remembered that it is to be taught as a drill procedure. The problems on the plate were selected with this in mind by offering sufficient practice to reduce it to the drill level.

VI Assignment:

1. Complete Plate 25

2. Study (F) Arts 117 to 120 (inclusive)

Lesson 27 (Oblique and cabinet projection)

I References (F) pp 131-138 (S) pp 166-172.

II Aim:

1. To teach the principles and relative advantages of oblique and cabinet types of pictorical projection.

III Specific abilities necessary to solve the plate:

1. A good reading knowledge of orthographic projection.

2. The ability to select the best location and angle to represent an object in oblique and cabinet.

3. To be able to decide wisely when a cabinet projection is preferable to an oblique projection.

4. A good working knowledge of the principles of oblique and cabinet projection.

IV Illustrative problem for blackboard use:

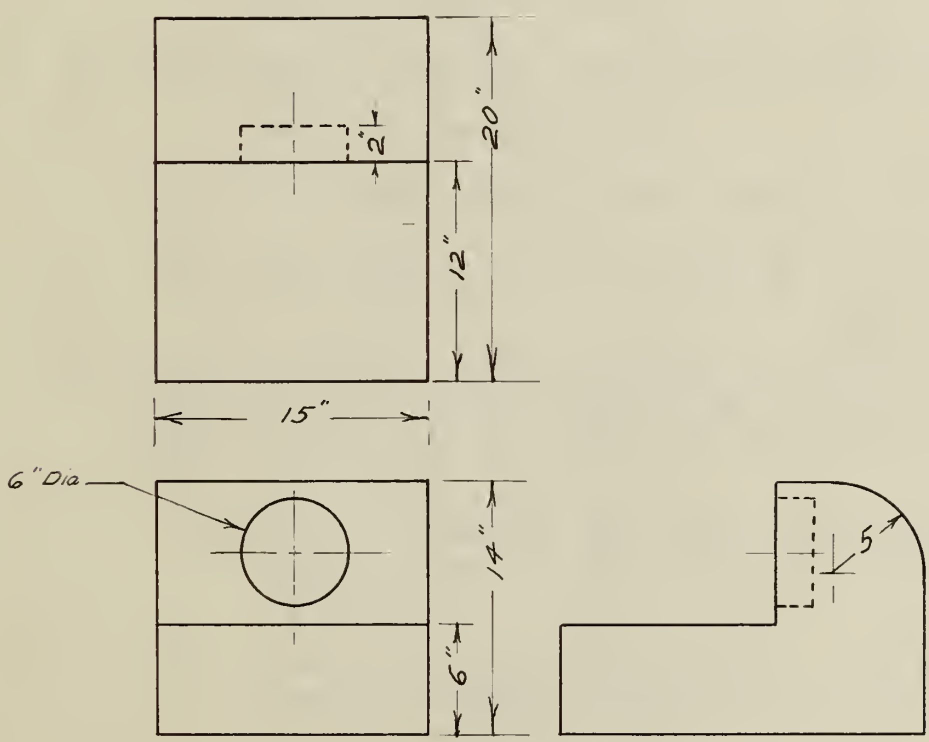


Fig 17

V Demonstration lecture:

1. The limitations of isometric projection.

    A. Noticable distortion due to lack of convergance of lines as they recede from the eye.

    B. Difficulty of drawing circles and irregular curves in isometric drawing.

2. Advantages of oblique and cabinet projections.

    A. Object may be placed to give a pleasing effect to the eye.

    B. Irrigular curves may be placed parallel to the plane of projection and easily drawn.

3. Rules of oblique and cabinet projection.

    A. Place the object with the irrigular outline parallel to the plane of projection.

    B. Preferably have the longest dimension parallel to the plane of projection.

4. The theory of oblique and cabinet projection.

    A. The oblique position.

    B. The real and projected angle.

    C. The relation of the position to the final drawing.

5. Solve the demonstration problem illustrating the following principles. (Make two projections of the same object, side by side, one in oblique and the other in cabinet projection.)

    A. That the length and widths and thicknesses of an object in oblique projection remain unchanged.

    B. That the length and widths in cabinet projection remain unchanged but the thicknesses become one-half size.

    C. That curves on surfaces parallel to the plane of projection are true shape and size.

    D. That curves on surfaces oblique to the plane of projection become distorted and must be co-ordinated.

E. That there is no set oblique angle or direction but may be selected to give the best view consistent with ease of drawing.

F. That parallel outlines on parallel surfaces remain parallel.

6. Explain the method of drawing objects having slant front surfaces by means of offsets from a right section.

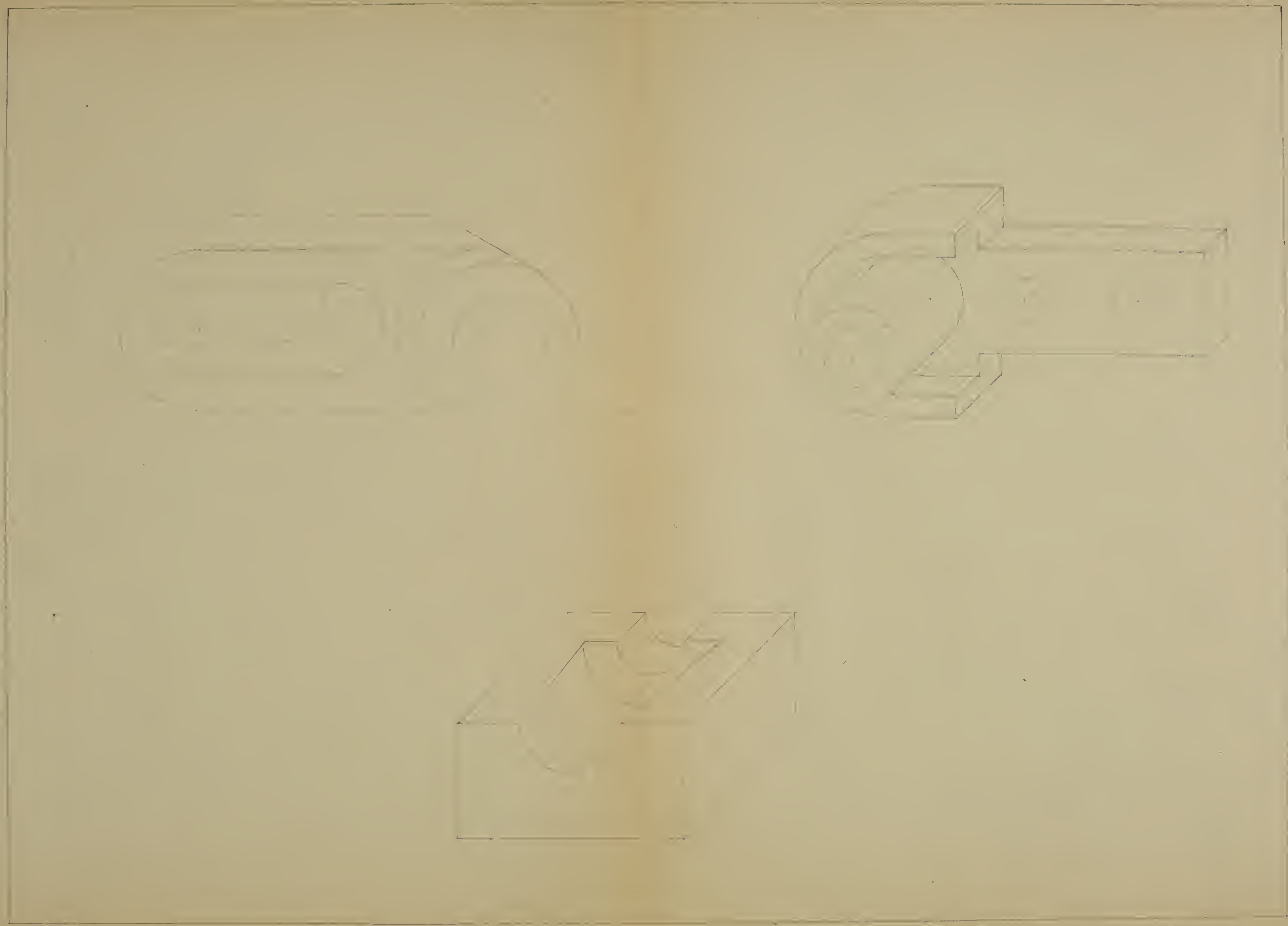
VI Assignment:

1. Complete Plate 26.

2. Study (F) Arts 245 to 248 (inclusive)

3. Read (F) Arts 249 to 258 (inclusive)

PLATE [illegible]



Lesson 28 (Perspective)

I References (F) pp 309-320.

Special Reference: Lubschez B. J. "Perspective"
D. Van Nostrand Co., New York,
3rd Edition, 1926.

II Aim:

1. To teach the fundamental principles of perspective as they relate to the solution of problems involving only one line of measure and two vanishing points.

III Specific abilities necessary to solve the plate:

1. To be able from a worded statement to locate the vertical and horizontal projections of a station point.

2. To know how to locate the vanishing points when the station points, picture plane and top view of the object are given.

3. To be able to make a perspective drawing with the use of one line of measure when the above points and a side view are given.

4. To stimulate a genuine interest beyond that of the vocational type.

IV Illustrative problem for blackboard use:

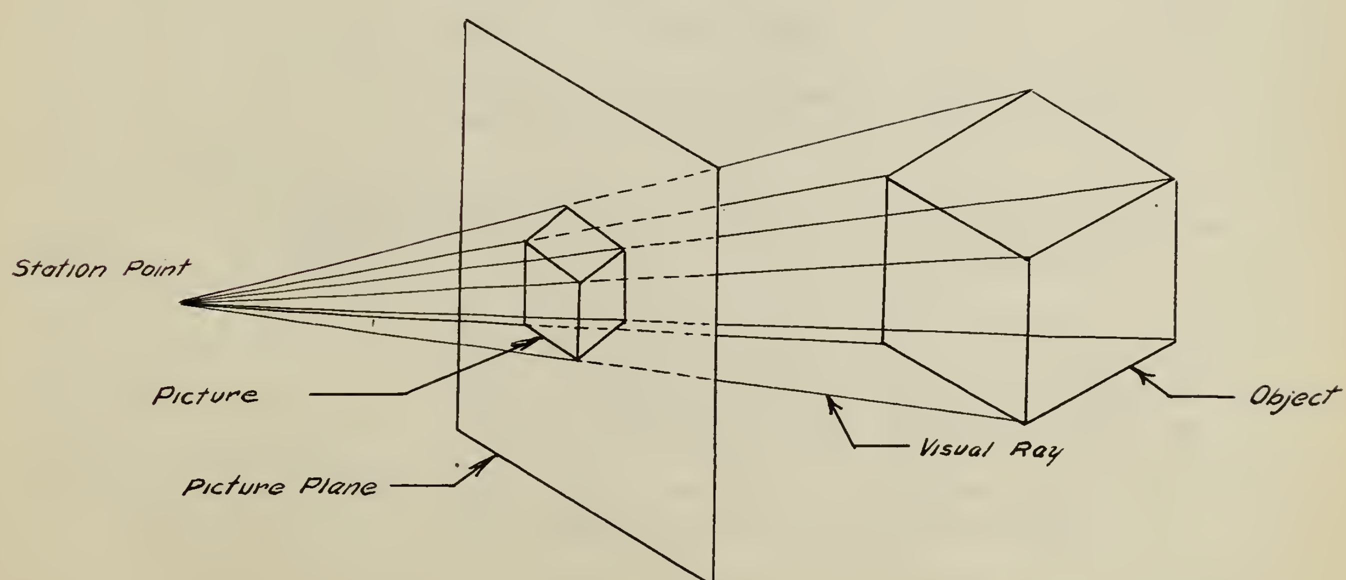


Fig 18

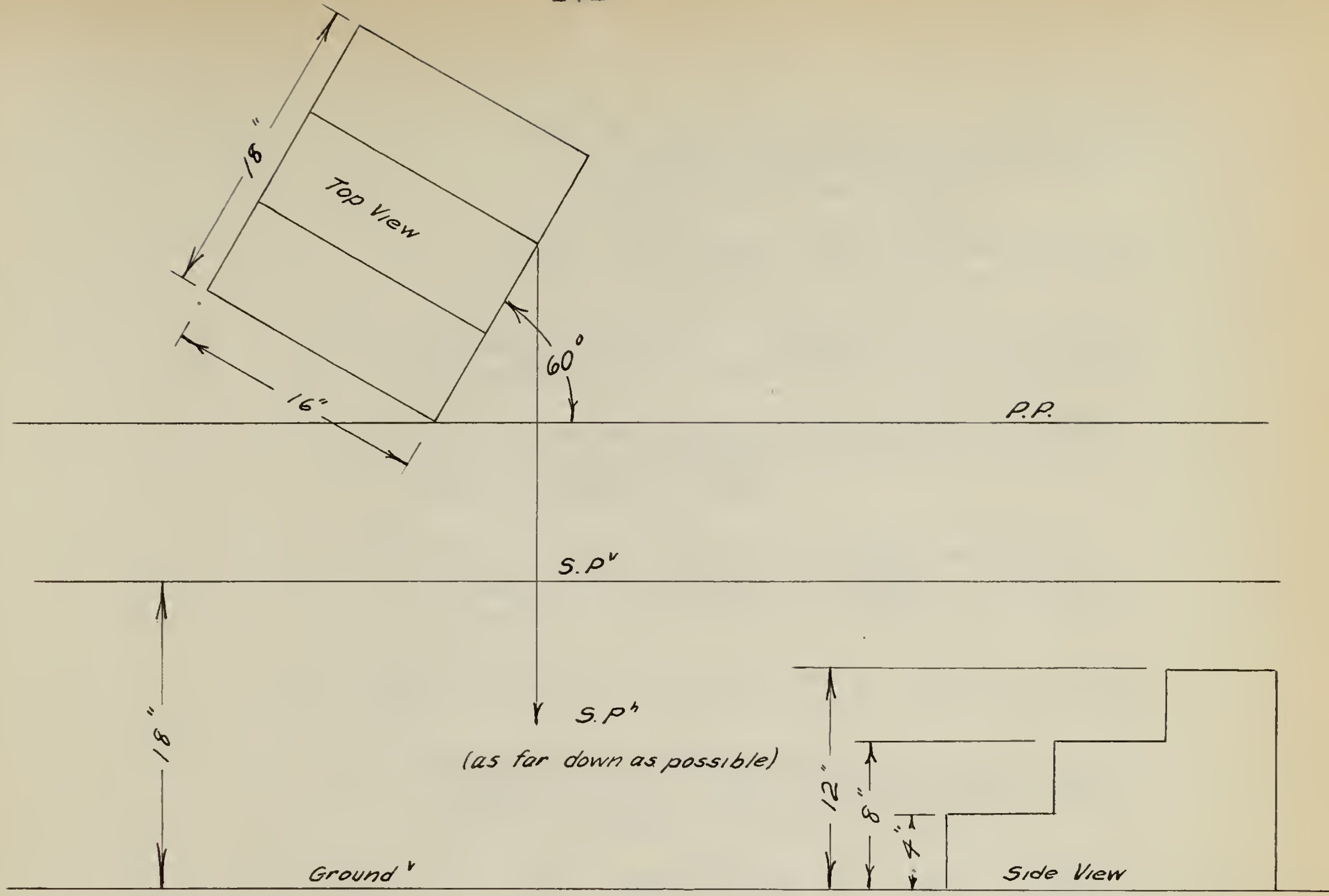


Fig 19

V Demonstration lecture:

1. Uses of perspective drawing:

   A. Show an object as it appears to the eye.

   B. Used by architects.

   C. Used to convey ideas to the layman by means of free-hand sketches.

2. By referring to the student's experiences, their study assignment and the first sketch given under heading IV deduce the following principles.

   A. That the visual rays all converge at the eye of the observer which can be made to vary according to his distance from the object and his height above the ground.

   B. That the size of the picture varies with the location of the picture plane.

      (A.) If the picture plane is in front of the object the picture will be smaller than the object.

(b) If it touches it, that edge which touches the picture plane will appear in true length.

(c) If behind, the picture will be larger than the object.

C. That a system of parallel lines will all disappear at a common vanishing point.

D. That the vanishing points are located on the horizon which is at the height of the observer's eye.

E. That there will be as many vanishing points as there are systems of parallel lines.

3. Solve demonstration problem in the following order.

A. Locate S.P.^{h} (Horizontal view of station point) at the given distance from the picture plane in front of corner C.

(a) May or may not appear below ground.

B. Locate S.P.^{v} which also fixes the horizon.

C. Draw from S.P.^{h} the two visual and obtain the two horizontal projections of V.P. (vanishing points.)

D. Obtain V.P.^{v}

E. Draw line of measure, visual rays and complete the perspective drawing.

F. Check for accuracy by continuing the step lines to vanishing points.

VI Assignment.

1. Complete Plate 27.


Picture Plane
Horizon
Station Point

Lesson 29 (Perspective)

I References (F) pp 309-320.

Special Reference--Lubschez B. J. "Perspective"
D. Van Nostrand Co., New York,
3rd. Edition 1926.

II Aim:

1. To provide further training in perspective drawing and to extend the previous treatment to include the solution of problems involving more than one line of measure.

III Specific abilities necessary to solve the plate:

1. An understanding of the work of the preceding lesson involving solving perspective problems requiring one line of measure only.

2. A working knowledge of the principle of obtaining the height of a surface in perspective that has no edge on it touching the picture plane.

IV Illustrative problem for blackboard use:

1. Draw on the board, free hand, a problem similar to the class problem and show how to measure and locate one surface by means of an extra line of measure.

V Demonstration lecture:

1. In explaining the extra line of measure it is well to consider the surface as being extended to touch the picture plane, measuring the true height on the extended surface and then by means of the visual ray cutting of that portion that is not needed.

2. Explain other methods of making perspective drawings.

A. Without the use of vanishing points.

(a) Draw profile as well as top views of object, picture plane and visual rays.

(b) Obtain widths from top and heights from side view where the rays intercept the picture plane.

B. By putting the plan in perspective and building vertically up.

(a) Used by architects.

3. Speak of review for final examination.

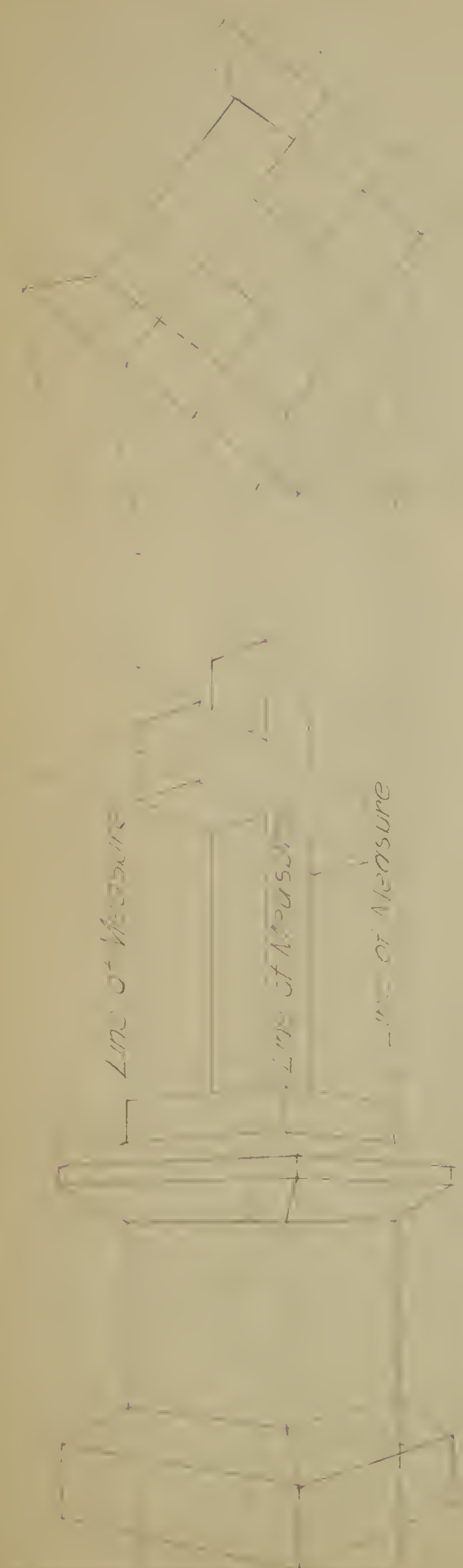
   A. If the new type of test is to be given stress knowledge.

   B. If objective graphical test is to be given list suggested problems from the text for review.

VI Assignment

1. Review for final examination.

PLATE 18



McGEARY J.G.

CHAPTER VI

Measuring Aptitude and Achievement in the Subject

Most of the differences between people are of a quantitative rather than of a qualitative nature. Unless we are badly deformed we can all run but just how well we can run requires some kind of a test. Even the fastest of our trackmen can be easily overtaken by a fast whippet dog. This implies that when we term a man as being fast we are refering to his speed relative to the other men and not with respect to some other species. This ability to run, which we all possess, is then a qualitative one while our relative speed of running is quantitative and must be expressed in terms of some standard that we are all familiar with.

For running we measure the quantitative element by determining the time necessary to travel over known distances. By this means we are able to compare the speed of a man on the east coast with one on the west coast. We do not doubt the relative performances because we know that personal opinion does not enter into the measuring devise which is based upon scientifically accurate time pieces and tapes, and that the units used are well standardized. Although not doubting the final performances we will very naturally seek an explanation as to why those from a certain section of the country always seem to excel in some one particular event. When we are told that an eastern runner can do a mile in four minutes and twelve seconds we should, if this were the second case from the same

locality be interested in knowing whether their speed was a property of their physical inheritance or of their training.

We have not gone very far with the subject of measurement without being in the very center of it. If we stop and analyze our discussion concerning the topic of running, we shall find that the following principles, which are of importance in the subject of measurement, have been covered.

1. That those differences for which we devise tests for measurement are practically always of a quanitative nature.

2. That in order that we may compare the standing of one person in an ability with another we must set up standards and express their relative difference.

3. That those quantitative differences must be due to a number of causes and if we are to attempt to predict a person's success we must know what those favorable factors are and the degree to which they are possessed by the person we are considering.

4. That our tests to stand comparison must be based on impersonal and scientific methods of grading.

With the above principles in mind we will consider them as they apply to our subject by first treating with the student's aptitude for the subject, then the various techniques used for measuring achievement in drawing and lastly the topic of standardized tests as they apply to our work.

A <u>The Problem of Determining a Student's Aptitude</u>.

By aptitude we mean a person's natural ability to be able to do a specified type of work independent of any previous training in that endeavor. If a good aptitude test could be designed we could predict a student's success in a subject

before he entered upon a study of the subject. Our next question might well be, why design a special test when we already have recorded his achievement in other subjects? Does it not follow that if a person does well in one subject he will do well in others? For some subjects this is true, as achievement in one correlates very highly with achievement with another making aptitude test unnecessary for predicting success or failure in the second subject. For many subjects we should think off hand that they would correlate but if we rely upon our judgment rather than upon a calculated result we shall many times be lead astray. It was for the possibility of finding a subject that would correlate very highly with drawing that the writer calculated the coefficients of correlation between success in trigonometry and drawing and success between English and drawing for a class of three hundred freshman at Northeastern University, Boston, Massachusetts.

The following tables give the distributions of the grades in the subjects referred to and below each table are the calculations necessary for computing the coefficient of correlation.

Calculation of the Product-Moment Coefficients of Correlation between the grades in Trigonometry and the grades in Drawing and between the grades in English and grades in Drawing for 300 college men.

Grades in Trigonometry

Grades in Drawing

	F	D	C	B	A	Total Fy	D	FD	FD²
A	0	0	5	9_{18}	9_{36}	23	2	46	92
B	1_{-2}	9_{-9}	23	27_{27}	7_{14}	67	1	67	67
C	2	6	21	19	7	55	G.A.		
D	5^{10}	31^{31}	33	15_{-15}	3_{-6}	87	-1	-87	87
F	18_{72}	21_{42}	18	6_{-12}	4_{-16}	68	-2	-136	272
Total Fx	26	67	101	76	30	300			518
D	-2	-1	G.A	+1	+2				
FD	-52	-67		76	60				
FD²	104	67		76	120	367			

Fig. 20

Grades in English

Grades in Drawing

	F	D	C	B	A	Total Fy	D	FD	FD²
A	0	1_{-2}	8	10_{20}	4_{16}	23	2	46	92
B	0	11_{-11}	40	14_{14}	1_{2}	66	1	66	66
C	0	6	26	13	2	57	GA		
D	2_{4}	33_{33}	38	14_{-14}	0	87	-1	-87	87
F	5_{20}	30_{60}	28	4_{-8}	0	67	-2	-134	268
Total Fx	7	91	140	55	7	300			513
D	-2	-1	GA.	1	2				
FD	-14	-91		55	14				
FD²	28	91		55	28				

Fig 21

$$\begin{array}{r|l} -11+ & 95 \\ \hline +155 & -49 \end{array} = \quad \Sigma x'y' = +190$$

$$C_x = \frac{136-119}{300} = .05667 \qquad C_x^2 = .00321$$

$$C_y = \frac{113-223}{300} = -.3667 \qquad C_y^2 = .135$$

$$\sigma_x = \sqrt{\frac{\Sigma FD^2}{N} - C_x^2} = \sqrt{\frac{367}{300} - .00321} = 1.104$$

$$\sigma_y = \sqrt{\frac{518}{300} - .135} = 1.26$$

$$r = \frac{\Sigma \frac{x'y'}{N} - C_x C_y}{\sigma_x \sigma_y} = \frac{\frac{190}{300} + (.05667 \times .367)}{1.104 \times 1.26}$$

$$r = 0.47$$

$$\begin{array}{r|l} -11 & +52 \\ \hline +117 & -22 \end{array} \qquad \Sigma x'y' = +136$$

$$C_x = \frac{-105+69}{300} = -.12 \qquad C_x^2 = .0144$$

$$C_y = \frac{-221+112}{300} = .3633 \qquad C_y^2 = .111$$

$$\sigma_x = \sqrt{\frac{\Sigma FD^2}{N} - C_x^2} = \sqrt{\frac{202}{300} - .0144} = .87$$

$$\sigma_y = \sqrt{\frac{513}{300} - .111} = 1.262$$

$$r = \frac{\frac{\Sigma x'y'}{N} - C_x C_y}{\sigma_x \sigma_y} = \frac{\frac{136}{300} + (.12 \times .363)}{.87 \times 1.262}$$

$$r = 0.452$$

The coefficients of correlation between trigonometry and drawing was found to be a 0.47, and the like figure between English and drawing to be 0.452. Neither of these results is significant enough to allow the subjects of trigonometry and English to be used as a basis for predicting probable success of a class of students in Engineering Drawing. We can conclude from this that success in drawing requires a different kind or degrees of ability than are required in the other subjects or

if the abilities are alike in kind and degree our means of measurement are so unreliable as to detect the differences between the two.

Our next concern is to find out just what abilities are necessary for success in drawing and then to see how they can be measured. The following are believed by the writer to be the outstanding characteristics that influence a student's success in the study of Engineering Drawing.

1. Interest in the subject.
2. Ability to visualize in two and three dimensions.
3. The senses of vision, touch and of pressure.
4. Muscular control especially that co-ordination between the hand and the eye.
5. Hand and finger dexterity.
6. Previous training in geometry and mechanic arts.

There are many tests such as the "Detroit Mechanical Aptitude Tests for Boys" the "Minnesota Paper Form Board Tests" the "Mac Quarrie Test for Mechanical Ability," and the "Stanford Scientific Aptitude Test" which have for their purpose the measuring of some one of these abilities together with others we have not listed, but the only test that has been made up to test aptitude for Engineering Drawing is one constructed by Dr. Clair V. Mann, Professor of Engineering Drawing and Descriptive Geometry at the University of Missouri.*

*Mann C. V. "Placement Examination in General Engineering Drawing" published by Department of Engineering Drawing School of Mines and Metallurgy, University of Missouri, Rolla, Missouri. A copy of this test is bound in the back of this thesis.

In addition to the other characteristics it measures factual knowledge in drawing which is so general that one interested in the subject would probably know it. If offers a means of measuring the student's ability to visualize in two but not in three dimensions. I wrote and asked Professor Mann if he had any tests for measuring ability to visualize in three dimensions. He replied that at present they did not but he believed that ability to visualize in three dimensions is closely correlated with the ability to visualize in two dimensions. He also informed me that the test was undergoing a second revision, the first test being issued August 1927, and the first revised copy issued August 1929.

This test of Professor Mann's has a coefficient of correlation of 0.626 and a coefficient of reliability of 0.81 which are satisfactory and high enough to justify its adoption. Other factors such as its attractiveness in appearance, ease of correction, objectiveness, ease of administration and completeness of directions are additional favorable considerations that would prompt its use.

Having decided that we have a test that can be used to measure the student's appitude for Engineering Drawing it is but logical that we next inquired into the use to which it may be put. The following are the outstanding uses to which an appitude test in our subject would be put.

1. Give us a basis to segregate our students into separate classes according to their ability.

2. To be one factor in the diagnosis of special cases and used as a basis of suggesting remedial measures.

3. To help differentiate between natural aptitude for the subject and training in the subject.

The objection to segregation of students on the basis of ability is that it is undemocratic and does not allow the duller or average students the opportunity to learn from the association with the brighter ones. Our educational system is adapted to the needs of the middle part of our class distributions resulting in the brighter students getting along with very little effort and many times actually being classed as possessing only average intelligence. The duller students either fall by the wayside or due to extra effort manage to do passing work. The solution to this is to have one or two bright sections, and one or two dull ones dividing the remainder of the students without respect to their rating on the aptitude test. Professor Henry W. Miller of the College of Engineering of the University of Michigan conducted an experiment on the segregation of engineering students on the basis of ability for the years 1923, 1924 and 1925 and concluded among other things that there is no apparent harm done to the student by segregating them with their mental equals.

The use of the aptitude test as an important factor in the diagnosis of special cases and used as a basis of suggesting remedial measures is an important one. Many students are lacking in the ability to visualize in two and three dimensions

and they can only hope just to pass the course as their objective. In order to be of value for this work there must be norms of attainment already set for the test in order that a student may be placed with respect to others of the same school.

The preceding function is closely allied to the one of differentiating between natural aptitudes for the subject and the training in the subject. By means of this test we can distinguish between the student who is bright but lazy and the student who receives the same grade but is dull and works exceedingly hard. This gives the instructor or adviser an opportunity to give intelligent guidance by being fair to the student and to the instructor.

B Techniques for Measuring Abilities in Drawing

We have made mention of the fact that drawing has not always been classed as a knowledge subject. When it first justified its place on the engineering curriculum it was taught as a skill subject with the mental discipline and abstract part of it studied under the name of Descriptive Geometry. At the present time this attitude has changed and Engineering Drawing is now considered as a knowledge as well as a skill subject. This is evidenced by the decided change in the character of the text books and in the methods of teaching. It is those teachers who still cling to the old idea that teach the subject on the laboratory basis without supplementing it with the lecture, demonstration or recitation methods. As a new part of this teaching program there has been introduced the technique of measurement which is also a direct outcome of the

changed conception of the make up of the subject.

Under the old plan the grade was obtained by averaging the plate marks which were previously determined by the subjective method of having the instructor pass judgment on the drawing skill displayed by the student. The method of solution played a very small part as most of the work was of a copy nature. The grades of the plates still play an important part in making up the final mark but the plates of today do not involve the copying type of problem that they previously did. The emphasis is now on the solution and method of attack with about twenty per cent of the grade being a factor of the drawing skill involved. It is still a question whether under the laboratory method of teaching the instructor is grading himself or the student. In the laboratory method referred to the instructor goes from bench to bench assisting the student by trying to help him help himself. Many teachers protect themselves against this by having the plates follow the demonstration lecture or recitation and have the plates done by the student under test conditions. When this practice is employed the class plate grades are treated as examination grades. If a freer use of the laboratory period is made the class plates are averaged and put together with test averages and sometimes home-plate averages to determine the final grade.

The technique of measurement as applied to Engineering Drawing has been very logical when viewed in the light of the conditions and practices that have been associated with and have surrounded the subject. The first type of tests given

are what we may refer to as test plates. That is when it was thought there was sufficient thought material to be measured, the instructor gave the class a plate to do containing problems very similar to those they had just completed. The greatest drawback to this plan was the loss of time involved. In doinga test plate requiring three hours for its completion more than half of that time was consumed in laying out the problems. This method was first overcome by the more progressive teacher, and later followed by practically all, by having the layouts of the problems printed on special test plates requiring the students to solve but not lay out any problems. If the test was to be orthographic projection the two given views would be printed with the appropriate space left for the student to draw in the third view. To cut down the time of testing, even further, a form of drawing completion test was devised. In testing orthographic projection with this type of test three incomplete views would be supplied the student for him to insert the missing lines or to change the character of the line for conventions used. The practices for cutting down the time have been paralleled by a decrease in the amount of time alloted to the subject on the curriculum and their adoption seemslogical from that point of view. Another factor influencing the change in methods of testing has been the growing literature and place the new type of test is having in the complete field of education. It is only within the last three years that the new type of examination has been

applied to our subject of Engineering Drawing and we will give it further consideration a little further on in this chapter.

In all of the types of tests just referred to the subject matter was of such a nature as to lend itself to an objective scale of grading. By this I mean practically all instructors would, on correcting the tests, point out the same errors. This does not mean that they would all allot the same grade or have the same errors. There would be a large variation in the grades due to the relative value the different instructors placed on the various parts of the problem. When the percentage system is employed this difference may be overcome to a large masure by considering the original percentage marking as scoring and making up the grades on the basis of the relative standing of one student with respect to another and the minimum acceptable score considered satisfactory for passing by the instructor. When grading by percentages the results will vary according to how difficult the problems are, the length of time allowed for the work, the relative value assigned to each problem and the leniency used in correction by the instructor. There being so many variable factors entering into the grading we could hardly expect to have any two instructors agree precisely on a set of examinations. In order to make the grading more uniform the plan of using the percentages as scores is recommended. This is especially adaptable when a test is given which proves to be too long for the time allotted. To illustrate its use,

the following score distribution which the writer obtained from a test he gave in drawing will be used:

Scores	No.	Grade
90-100	5	A.
80-90	4	B.
70- 80	3	C.
60- 70	3	C.
50- 60	5	D.
40- 50	4	D.
30- 40	3	D.
20- 30	3	F.
10- 20	2	F.
0- 10	1	FF.

From inspection, it is readily seen that the distribution was far from a normal one. Had I adhered to an old percentage passing grade of 60% eighteen would have failed and only fifteen would have passed. This condition would have been unfair because as it happened, due to unforeseen circumstances, the students did not have sufficient time for the middle or lower group to do justice to themselves. In determining what the limitating passing score should be my subjective judgment had to be used by inspecting the examinations and deciding which ones displayed enough working knowledge for the time they had to do it in, to be considered passing. Having decided this, the natural grouping of the distribution, while not normal, gave a basis for the rest of the grades. If the instructor would, in making up a test, list the abilities he wants to measure, make up problems to measure these abilities, decide upon the relative score to be given for each part, and then after the test has been given to score it on the predetermined basis and from a study of the test and score distribution

assign grades much of the subjective or personal elements would disappear from our marking system. It will be noticed that no mention is made here of the normal curve or of the statistical methods of assigning grades by first computing the median, mean or standard derivations or quartitals. The use of these methods has been purposely omitted to simplify the work by suggesting a working method embodying the advantages of recent educational practices that can be used by those engineering teachers that have not received a training in educational measurement.

The plan just suggested has been an attempt to revise the traditional testing procedure by eliminating, as far as possible, the subjective element in grading. In doing this we have revised an older method to attempt to approach perfection. Our treatment would be incomplete if we omit to take up, at this point, the new type of test which, although recognizing certain limitations, we now consider as that goal of perfection with respect to measuring abilities on a purely objective basis.

The new type of test consists of the large number of short exercises which can be answered by means of a check, inserting word or line, or by writing a numeral in the correct place. This form of examination possesses the following advantages:

1. A wide range of subject matter can be examined in a relatively short time.

2. The scoring is highly objective.

3. The subject matter to be measured can be singled out and measured separately without making the answers obscure.

[illegible]

4. Statistical results may be calculated which are of use in comparing tests and accomplishments from time to time.

5. The effort of writing is reduced for the student.

6. They are easy to correct by means of keys.

7. They are easy to administrate.

The advantages just listed are impressive, but when applying this form of test to engineering drawing, it should be remembered that we are only measuring the knowledge of the subject and not drawing skill, that many of the items are of the recognition type rather than of the creative, that problem solving ability of the simpler type only is measured. These advantages would be more serious if this test were to be the only basis of a grade. When it is considered that the student does approximately a class plate a day, where a good indication of his drawing skill can be obtained, and that the type of tests previously referred to measures his ability to solve different problems it logically follows that the new type of test has a place on the measuring program for testing those abilities and subject matter on those only that it is designed to test effectively.

In order that we understand the common terms as applied to educational measurement and at the same time familiarize ourselves with the outstanding requisites for the new type examinations we will understand the meanings of objectivity, validity, and reliability.

When we say that a test is objective we mean that the personal element has been eliminated from the scoring process.

It would make no difference who scored the examination as to the results obtained. The answers to the questions contained in a purely objective test would be scored by means of a key sheet or form which would not lend itself to two or more answers to any one question.

For a test to be valid it must measure only what it is designed to measure. These requisits limit the material of the test to only that which has been previously studied in the course that is being tested. If we want to measure a boy's ability to solve a perspective problem and we so confuse the layout and statement that due to his weakness or orthographic projection he cannot get started we should not have a valid test. We would be measuring his ability to solve orthographic projection problems and to obtain meanings out of purely phrased sentences rather than perspective projection. The conclusion is that we should have each item stand as far as possible on its own feet and have it concerned only with that which we are attempting to measure.

Reliability is concerned with the consistancy with which it measures what ever it does measure. Regardless as to whether the items are valid or not if the test is reliable the same students will obtain approximately the same score on the test if given again under the same conditions. This factor of reliability is represented by a numerical co-efficient which may be calculated by statistical methods.

In order to apply this form of educational measurement directly the writer here inserts a new type of objective test

that would serve as a final examination for our course of study.

Achievement Test in Engineering Drawing

I

Read these statements and make a "+" mark at the left of each statement if you think it is a true, and a "—" mark if you think it is false.

Don't guess! A wrong response counts heavily against you. Omit statements about which you know nothing.

A statement is true only if every part of it is true; a statement is false if any part of it is untrue.

— 1. Engineering drawing is a fine art.

— 2. The capital letters, A, B and F should be the same width.

— 3. The letters M and W should be the same width.

— 4. The distance between all capital letters is the same.

+ 5. Only one orthographic projection of an object can be drawn on one projection plane.

+ 6. The height of the front view is the same as the height of the side view.

— 7. An orthographic drawing always has three views.

+ 8. An angle of 75° may be obtained by means of the "T" square and triangles.

— 9. When using the scale $1\frac{1}{2}$" equals one foot, the dimension of 2'-3" will be represented by a line $3\frac{1}{4}$" long.

+ 10. You should not use a protractor to secure an angle of $52\frac{1}{2}$ degrees.

— 11. When a line is parallel to the horizontal it will show in its true length in the side view.

— 12. A right circular cone can be changed into an elliptical cone by means of a cutting plane oblique to its axis.

+ 13. A 105 degree angle can be constructed with the aid of the "T" square and triangles.

— 14. In drawing horizontal lines the lower edge of the "T" square may be used.

+ 15. A pentagon has five sides.

+ 16. The directrix of an oblique circular cone is a circle.

— 17. The ellipse as drawn by the pen and string method is only an approximation.

— 18. In addition to the major and minor axis the distance between the foci is needed before a trammel can be made.

+ 19. Only one triangle can be constructed from those given sides.

— 20. The side of an octagon is equal to the radius of the circumscribed circle.

+ 21. Only one measurement is necessary to make a regular hexagon by means of "T" square and triangle.

+ 22. For all practical purposes a 5 to 2 slant, an 8 to 3 slant, and a 70° slant may be used interchangeable.

+ 23. The height of the point of sight determine the heights of the vanishing points above the ground.

— 24. All horizontal lines in an isometric drawing show in true length.

+ 25. Perspective drawing is known as conical projection.

— 26. A circle drawn in perspective is not an ellipse.

— 27. No angle shows in its true size in an isometric drawing.

— 28. In perspective drawing when the picture plane is in back of the object the picture is smaller than the object.

— 29. A visual ray is a line connecting a point on the drawing with the vanishing point.

+ 30. If there are four different systems of parallel lines in an object then there will be four vanishing points in the perspective drawing.

— 31. Only curved lines are non-isometric lines.

+ 32. All dimensions are not size dimensions.

— 33. Three dimensions are necessary to describe the size of a right circular cylinder.

+ 34. Never require a workman to add or subtract dimensions.

+ 35. Fractions must be made with a horizontal division line.

— 36. Dimensions should be so placed that the drawing is readable from the bottom and left side.

— 37. A center line may be used as a dimension line.

+ 38. Drilled holes should be located from finished surfaces.

— 39. If a line is visible in one view it is visible in all views.

+ 40. The development of a right cylinder is a rectangle.

+ 41. The surface of a sphere cannot be developed.

+ 42. In dimensioning, all notes should read horizontally.

— 43. The development of a right circular cone is triangle.

+ 44. An auxiliary cutting plane is used in intersection problems.

+ 45. All lines in a development are true lines.

+ 46. An auxiliary view is used to determine the true size of a slant surface.

+ 47. It is necessary to put finished marks on a detail drawing.

— 48. In a section view if rods, bolts, or screws fall in the path of the cutting plane they are sectioned.

+ 49. In an oblique drawing a circular hole will show as a circle if it is on a face parallel to the plane of projection.

— 50. If an assembly drawing is sectioned all the cross hatch lines are parallel.

+ 51. In representing an object in the second quadrant the plane view may or may not be below the front view.

— 52. In perspective drawing the visual elements are parallel to the visual rays.

— 53. An oblique drawing is always drawn 45° to the right.

— 54. It is often permissible to use the scale as a straight edge in drawing a line.

+ 55. In perspective drawing the size of the picture is decreased by increasing the distance from the observer to the picture plane.

— 56. If two solids intersect then every line of one solid will pierce some surface on the other.

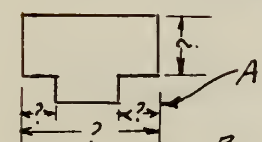
+ 57. If a triangular pyramid goes completely through a rectangular solid there will be an even number of points of piercing.

\+ 58. If the axis of two cylinders of different diameters intersect there will be two separate curves of intersection.

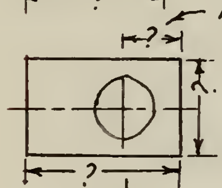
— 59. If a line pierces the base of a rectangular solid and is parallel to the side then it must also pierce the top of the solid.

II

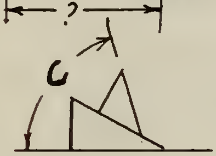
1. For each of the questions below write the number ofthe correct answers in the square at the right.



Line A is (1) a dimension line, (2) a section line, (3) a cross hatching line, (4) an extension line. $\boxed{4}$

2. 

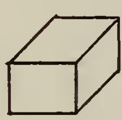
Line B is (1) a size dimension, (2) a tolerance dimension, (3) a location dimension, (4) an over all dimension. $\boxed{3}$

3. 

Angle C is (1) 60 degrees, (2) 85 degrees, (3) 75 degrees, (4) 105 degrees. $\boxed{3}$

4.

This is a (1) section line, (2) an invisible line, (3) a center line, (4) an extension line. $\boxed{3}$

5. 

This is (1) a perspective, (2) an oblique, (3) an orthographic, (4) an isometric drawing. $\boxed{2}$

III

Complete the following sentences by supplying the proper word or words that are missing. These statements when completed should be true statements.

1. The diamter of a circle must be made a little -Larger---- than the side of a square in order to look the same size.

2. The length of the front is the --same--- as the -length-- of the top view.

3. Invisible edges are represented by -dotted---- lines.

4. The height of lower case lettering is equal to two thirds the height of the capital.

5. The space between two lines of lettering in a title is equal to the --height--- of the -smaller-- of the two lines.

6. The hole represented by two parallel dotted lines equally spaced with respect to a center line in both the top and side views shows in the front view as a ----circle---- or a symmetrical curve.

7. The difference between isometric drawing and isometric projection is that the drawing is not--true size while the projection is ---true--size---.

8. The hyperbola is obtained by a cutting plane making an --angle-- with the axis --smaller-- than that of the elements.

9. An ellipse is a curve generated by a point moving in a plane so that the --sum--- of its distances from two fixed points is a --constant--.

10. In making an oblique drawing it is easiest to have the irregular or curved surfaces --parallel-- to the plane of projection.

11. In cabinet drawing the distances back from the front surfaces are equal to -one half-- the same distances in an -oblique----- drawing.

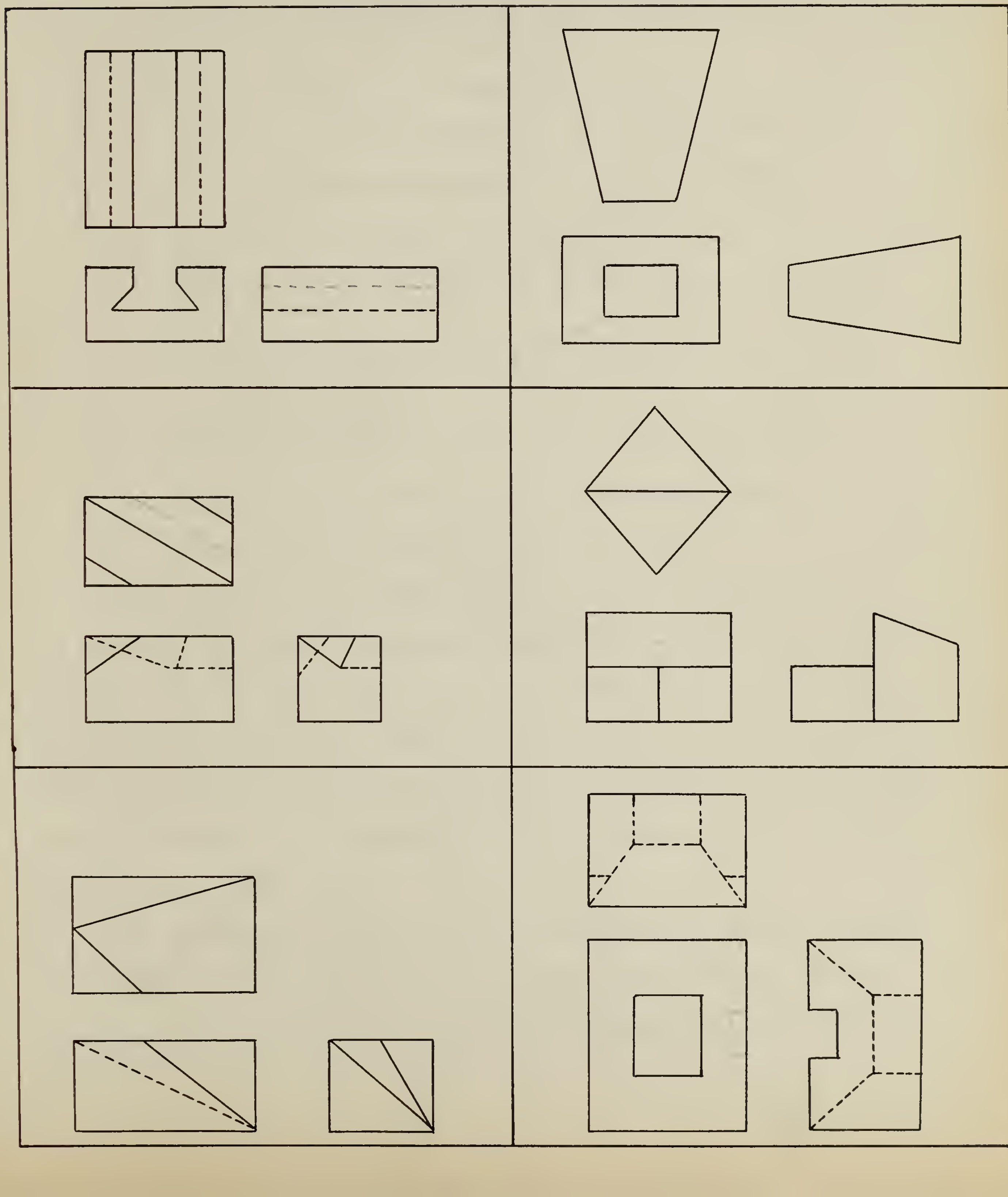
12. The parabola is a --curve-- generated by a point moving in a plane so that its distance from a fixed point equals its distance from a fixed ---line----.

13. To revolve an object without changing its height it must be revolved about an axis --*perpendicular*--- to the -*horizontal*-- plane.

14. For showing the inside of an object a --*section*---- drawing is best.

IV

Each of the objects is represented by three views. In some one of the three views there is a line or lines missing. Draw the missing lines in free hand for each object so that the drawing will be complete.



In the preceding test the following principles, which should be considered in constructing an examination of this type, were adhered to:

1. That at the beginning of each separate part there should be specific directions for doing that part making it unnecessary for any further explanations on the part of the examiner.

2. That at least fifty questions should be in a test.

3. That no statement should be in an ambiguous form.

4. That each question should be a unit in itself.

5. That the first few questions should be easy.

6. That the order of the true false questions should be at random.

7. That enough items should be included to cover the complete course.

8. That the wording of each item should be brief and clear.

9. That the test should be easy to administer.

10. That the test should be easy to score.

After the test has been given it should be scored, a percentile curve of the scores constructed, the curve and border line tests studied, and the points on the curve corresponding to the five grades to be awarded should be allotted. The grades in letter form should then be recorded on the final record sheets to be balanced with the other grades in determining the final grade.

The achievement test we just considered is generally made up by the instructor giving the course and is built around what he thinks to be the important knowledge outcomes of the

course. There is another type of objective test called the standard test which is concerned with fundamentals that have been standardized to the extend of being incorporated into all good courses of study. These tests have forms of attainment which may be used to measure the relative achievement of one group with respect to another as well as offering the instructor an opportunity to weigh the relative merits of this course of study and method of teaching. In order that we bring our discussion down to a tangible basis we shall do well to make our points by illustration. Therefore, we will concern ourselves with a critical study of a "A series of Standard Tests in Fundamental Mechanical Drawing," published by the Public School Publishing Company of Bloomington, Illinois, and constructed by Alex. B. Badger.*

As the subject matter of these tests has been divided into three sections rather than one general test we will first discuss each section separately and then consider the test as a whole. The divisions as made by the author are logical and as he explains in the manual the division is made since the order of presenting the various subjects covered vary in different schools.

Test one is concerned with measuring the student's ability in use of tools, line work, dimensioning and lettering. Although these abilities are very necessary for success in drawing room work they are not good topics to be included in a standard test. This is true because much of the work is merely

*A copy of this test is bound in the back of this thesis.

conventions which are not completely standardized, or they are practices which vary according to drawing-room conditions, type of student, particular school and instructor. In order to illustrate this point we will take as an example item (3) which is a mutiple choice item and reads as follows:

"In using triangles with the T-square for ruling vertical lines, always have the vertical edge of the triangle toward the (right) (left) (either right or left)." The answer given in the manual is the left side but in many schools where small drawing boards are used the T-square must at times be used with the vertical edge to the right and also where the light is bad, or where the boy is left handed.

Item five is wholly a conventional practice but it is fairly well standardized and may be permitted. In items 34 to 38 which are concerned with weight of line the correct answer would be correct relatively only; that is, the heaviest line would be checked for border line while in actual practice a student may be taught to use a much heavier line for the border line. The line checked for the center line may be used correctly with respect to weight, but the center line is seldom a full line, as shown in the test. This would be confusing to the student.

So far consideration has been given to use of tools, line work, and dimensioning which leaves lettering as the remaining feature of test one. Of a total of 75 points assigned to this first test 36 are on lettering. This distribution may

be justified if the student's ability on lettering could be correctly measured but I very much doubt the validity of the test. The test is wholly a recognition test and is more a measure of general intelligence than of any specific technical knowledge. To check my opinion on this I gave this section of the test to ten different people who had never studied the subject and they checked an average of twenty-seven out of the thirty-six items correct. If they can obtain a possible 27 out of a total 36 points without any knowledge of the subject the test can hardly be measuring what it is intended to measure.

Test two examines the most important part of Mechanical Drawing; namely, that of projection, including sections and auxiliary views. This test is well constructed and each item used is a fair one for a standard test.

Test three is on three common types of pictorical drawing called isometric, cabinet and oblique. The items of this test are so selected that they cover the important principles of pictorical drawing and all in all makes a good standard test.

In considering the three tests as a unit I would say that not enough weight had been given to test 2. This test measures the most important part of the subject while it receives the smallest possible score. The highest score obtainable in test I is 112½, in test 2 it is 100, while in test 3 it is 105.

The standards for these tests are in preparation so the tests as they now stand are really not standard tests as they

have no norms.

The make-up of the test does not follow a good course of study as work on geometric, constructions, development and intersection are omitted. These topics are included in all the good text books such as those given in the bibliography of this thesis and all good courses of study. To be definite I refer to the courses of study that I looked over which are those of the Boston schools, Lynn schools, and the Gloucester schools. These subjects are also included in Svensen's "Instructors' Manual for Mechanical Drawing," and in the outline given in Hoelscher's"Teaching of Mechanical Drawing." The subject of perspective is covered under the division of pictorical drawing in many schools but it is a question as to whether the practice is wide enough to warrant a place for it in a standard test.

With respect to the mechanical features of the tests I would say that they are attractive with clear and simple directions for the students, which makes them easy to administer. There is no time limit on the test so that the students should feel under no strain when they take them.

Although the manual is complete with respect to directions for scoring, the scoring would take considerable time due to the scoring value of the various items. Some items receive one score unit, some one-quarter, some one-third and others one-half a unit. The assigning of the proper score value and the adding of them would involve considerable time as would

the correction of those items requiring the addition of the missing lines in a drawing.

The paper is of good quality and the cost should not be prohibitive to any school system wanting to use them.

In conclusion let it be said that at their best they can only measure knowledge and not technique. When taking into account those topics that are omitted and realizing that the first test is of little value I would not use the Badger tests and consider them as a means of obtaining a picture of the students knowledge of the subject.

BIBLIOGRAPHY

Books---The complete book was referred to unless specific pages or chapter, are indicated.

1. Anthony G. "An Introduction to the Graphic Language, D. C. Heath Company, Boston--1922.

2. Anthong G. Ashley G. F. "Descriptive Geometry" D. C. Heath Company, Boston, 2nd. Edition--1926.

3. Barr A. S., Burton W. H. "The Supervision of Instruction" pp 187-280, D. Appleton & Company, New York--1926.

4. Daniels F. T. "Free-Hand Lettering" D. C. Heath Company, Boston--1907.

5. Douglas H. R. "Modern Methods in High School Teaching" pp 31-100, Houghton Mifflin Company, Boston--1926.

6. Elliot E. C. "City School Supervision" p 12, World Book Company, New York--1914.

7. French F. E. "Engineering Drawing" McGraw-Hill Book Company, New York, 4th Edition--1929.

8. Garrett H. E. "Statistics in Psychology and Education" Longman's Green Company, New York--1926.

9. Hoelscher R. P. "Teaching of Mechanical Drawing" John Wiley & Sons Inc., New York--1929.

10. Hood G. J. "Geometry of Engineering Drawing" McGraw-Hill Company, New York--1926.

11. Hopkins L. T. "Curriculum Principles and Practices" pp 1-240, Benj. H. Sanborn Company, New York--1929.

12. Jorden H. H. & Hoelscher R. P. "Engineering Drawing" John Wiley & Sons Inc, New York, 2nd Edition--1928.

13. Klapper Paul, "College Teaching" Chapter XXV (The Teaching of Engineering)Subjects) by Baker, Iva O. and Chapter XXVI (The Teaching of Mechanical Drawing) by Phillips J. D. and Orth H. D., World Book Company, New York--1920.

14. Lubschez B. J. Perspective, an elementary text book, D. Van Nostrand Company, New York, 4th Edition--1927.

15. Mann C. V. "Objective Type Test in Engineering Education" McGraw-Hill Company New York--1930.

16. Monroe W. S. "Directing Learning in the High School" Doubleday, Doran & Company, Inc., New York--1928.

17. Paterson D. G. "Preparation and Use of New Type Tests" World Book Company, Yonkers, New York--1925.

18. Reeder W. G. "How to Write a Thesis" Public School Publishing Company, Bloomington, Illinois, 2nd Edition--1930.

19. Stormzard M. J. "Progressive Methods of Teaching" Houghton Mifflin Company, New York--1924.

20. Svensen C. L. "Drafting for Engineers" D. Van Nostrand Company, New York--1927.

21. Svensen C. L. "Machine Drawing" pp 38-72, D. Van Nostrand Company, New York--1923.

22. Wilson-Kyle-Lull "Modern Methods of Teaching" pp 122-138, Selver Burdett & Company, New York--1924.

23. Zipprich A. E. "Freehand Drafting" D. Van Nostrand Company, New York--1924.

-II-

Published Material

1. Badger A. J. "A Teacher's Manual and a Series of Tests in Fundamental Mechanical Drawing" Public School Publishing Company, Bloomington, Illinois.

2. Baker H. J. Crockett A. C. "Detroit Mechanical Aptitude Examination for Boys" Public School Publishing Company, Bloomington, Illinois--1928.

3. Chapman J. C. "Need Measurement in Engineering Education" Journal of Engineering Education, Vol. XII No. 8, (April 1922) pp 348-352.

4. French T. E. "The Objectives of Courses in Drawing and Descriptive Geometry" The Journal of Engineering Education, Vol. XXI No. 1 (Sept. 1930) pp 72-79.

5. Hammond H. P. "The Engineering Curriculum" The Journal of Engineering Education, Vol. XVIII No. 1 (Sept. 1927) pp 57-84.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

6. Hegbee F. G. "History of the Development of Graphical Representation" The Journal of Engineering Education, Vol. XXI No. 3 (Nov. 1930) pp 237-255.

7. Jorden H. H. "Org. & Adm. of the Drawing Dept." The Journal of Engineering Education, Vol. XXI No. 3 (Oct. 1930) pp 166-172.

8. Mann C. V. "Placement Examination in General Engineering" Published by Department of Engineering Drawing, Schools of Mines and Metallurgy, University of Missouri, Rolla, (Revised Edition--August 10, 1929).

9. McCully H. M. "The Content of an Engineering Drawing Course" The Journal of Engineering Education Vol. XXI, No. 7 (March 1931) pp 526-528.

10. Minnesota Paper Form Board Test" Published by the Department of Psychology, University of Minnesota.

11. Poole F. "The Chinese Language Old and New" The Literary Digest (March 12, 1927) p. 46.

12. Taylor E. "Academic Graphics" The Journal of Engineering Education, Vol. XXI, No. 9 (May 1931) pp 616-617.

13. Wilcox E. R. "Placement Tests as a means of Predicting Failures in First-Year Work in Engineering at the University of Washington" The Journal of Engineering Education, Vol. XX, No. 3 (April 1930) pp 791-794.

14. Zyre D. L. "Stanford Scientific Appitude Test" Stanford University Press, Stanford University, California--1929.

15. "Outline of Courses in Art" for the Boston Public Schools, Published by the school committee of the City of Boston, Massachusetts.

16. "Supplementary Guidance Bulletin" for the Gloucester High Schools, Published by the School Publishing Department, Gloucester, Massachusetts.

III

Unpublished material.

All of the following material is in mimeographed form and was presented by the writers before a meeting of the Division of Drawing of the Society for the Promotion of Engineering Eduction at Pittsburg, Pennsylvania, June 1930:*

1. Furman F. D. "The Relationships of Engineering Drawing Courses to the Engineering Curriculum" Presented June 12, 1930--5pp.

2. Hoelscher R. P. "The Use of the Recitation in Teaching Drawing," Presented June 16, 1930--17pp.

3. Hood G. J. "A Survey of the Methods of Teaching Descriptive Geometry" Presented June 17, 1930, 6pp.

4. Mann C. V. "Tests and Measurements in Engineering Education" Presented June 14, 1930, 12pp.

5. Mann C. V. "Examinations and Tests of Achievement" Presented June 21, 1930, 14pp.

6. Miller H. W. "Segregation of Students on the Basis of Ability" Presented June 14, 1930, 17pp.

7. Schumann C. H. "The Use of the Recitation Period in Descriptive Geometry" Presented June 17, 1930, 12pp.

8. Smith W. G. "The Use of the Laboratory Period in Descriptive Geometry" Presented June 17, 1930, 8pp.

9. Svensen C. L. "The Problem Question: Source, Presentation, Laboratory Methods" Presented June 16, 1930, 18pp.

10. Thomas C. W. "The Drafting or Laboratory Period of Descriptive Geometry" Presented June 17, 1930, 3pp.

11. Warner F. M. "Development of a Course in Engineering Drawing" Presented June 19, 1930, 13pp.

* Copies of these papers may be obtained, for cost of printing, by writing to the office of the Secretary, F. L. Bishop, University of Pittsburg, Pittsburg, Pennsylvania.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Paper No.................. Section No..................

MISSOURI SCHOOL OF MINES ENGINEERING EDUCATIONAL TESTS

Unit No. 2, GED-A

(Revised Edition, August 10, 1929)

PLACEMENT EXAMINATION

IN

GENERAL ENGINEERING DRAWING

(APTITUDE)

PREPARED AND PUBLISHED BY

DEPARTMENT OF ENGINEERING DRAWING

SCHOOL OF MINES AND METALLURGY

UNIVERSITY OF MISSOURI

ROLLA

Student's Name: .... (Surname) .... (Initials) Sex .... Yrs. .... (Age) Mos. ....

High School Attended .... City .... State ....

Institution Where Administered .... Date ....

Section .... Instructor .... Room ....

SCORING DATA

Maximum Possible Score: 200

Allowable Time: Total, 100 minutes.

Cover Page ..... 1 min.

Part A	4 "	Part 4	15 min.
Part 1	15 "	Part 5	10 "
Part 2	15 "	Part 6	15 "
Part 3	10 "	Part 7	15 "

Student's Score:

	Rights	Wrongs	Omits	Score
Part A				
1				
2				
3				
4				
5				
6				
7				
Totals				

CONSTRUCTED BY CLAIR V. MANN,
Professor of Engineering Drawing
and Descriptive Geometry.

NORMS.

On August 10, 1929, 341 students had taken this test at Missouri School of Mines, and 58 at State University of Iowa, making a total of 399. Papers of these students furnish the following data:

Perfect or maximum possible score	200
Lowest possible score	0
Highest score made to date	131
Lowest score to date	17
Average score of upper 25% of class	96.4
" of lowest 25% of class	32.1
Upper quartile	87
Lower quartile	56
Median score	71.43
Arithmetic mean of scores	71.46
Standard Deviation of distribution	22.12
Probable error of an individual score	6.41
P.E. score ÷ S.D.	0.29
r_x, coefficient of reliability	0.81 ± 0.018
Coeff. of correlation with first semester grades in engineering drawing (Pearson product-moment)	0.626 ± 0.034

Department of Engineering Drawing

SCHOOL OF MINES & METALLURGY

University of Missouri

Rolla

MANUAL OF DIRECTIONS

PLACEMENT EXAMINATIONS IN GENERAL ENGINEERING DRAWING.

CONSTRUCTED BY CLAIR V. MANN

ADMINISTRATION:

(1) For test in Engineering Drawing, Aptitude, all instruments and materials required will be furnished by the department. The materials required are: a pencil of "H" hardness (Van Dyke 601 No. 2), a 6″ straight edge, and a pen-pencil compass. For the test in Engineering Drawing, Training, the complete set of instruments as shown in Plates 1 and 2 on Page 8 is required. The students should be told in advance to bring these to class for the examination.

(2) Arrange the students in alternate seats if possible; in any event careful surveillance is necessary throughout the examination.

(3) One assistant will be needed for every 25 students.

(4) It is important that every examination booklet be accounted for.

(5) Note that all students work on the same part at the same time.

(6) As the time of the class hour is closely apportioned, the following steps must be executed with precision:

- (a) Seat the students (See 2 above).
- (b) Furnish each student with equipment necessary in (1) above if the test being given is for Aptitude.
- (c) If the test is for Training, be sure that each student is provided with the tools that must be used in the test.
- (d) Pass out the examinations, placing each one face up on the desk, but inverted so that the student cannot read it.
- (e) Then say: **"Your score in this examination will depend upon the number of questions answered correctly. It is to your advantage to obtain as high a score as possible. However no one is expected to be able to answer every question. Now turn the folders about and fill out the three lines at the bottom of the title page."**
  (Examiner points to them. Allow about 1 minute for this).
- (f) Then say: **"Turn to Page 3 read the 'Directions' near the top of page 3."**
  (Examiner reads them aloud, while students work silently.
- (g) Then say: **"Ready, begin work on part A,"** and record the exact time.
- (h) After (   )* minutes say: **"Stop, turn over the page; fold the second sheet under; and begin work on Part 1."**
- (i) After (   )* minutes say: **"Stop, turn over the folder and begin work on Part 2"** and record the exact time.
- (j) After (   )* minutes say: **"Stop, turn over the page; fold the third sheet under, and begin work on Part 3,"** and record the exact time.
- (k) After (   )* minutes say: **"Stop, turn over the folder, and begin work on Part 4,"** and record the exact time.
- (l) After (   )* minutes say: **"Stop, turn over the page; fold the fourth sheet under and begin work on Part 5,"** and record the exact time.
- (m) After (   )* minutes say: **"Stop, turn over the folder, and begin work on Part 6,"** and record the exact time.
- (n) After (   )* minutes say: **"Stop, turn over the page, and begin work on Part 7,"** and record the exact time.
- (o) After (   )* say: **"Stop writing."**
- (p) Gather all examination folders immediately.

*Time limits for each part are printed on the examinations.

SCORING:

(1) The weighting of the parts is printed on the examinations, and is in the scoring keys. Correct answers are given in the keys. It is suggested that for the T-F, R-W, and multiple response type of question, the answers be copied on a narrow strip of cardboard and properly spaced to conform to the printed questions. For other types it is convenient to copy the correct answers on a test-blank.

- (a) Items correctly answered should be checked with a blue or red pencil. No half credits are allowed.
- (b) All fractions should be dropped from the part scores.
- (c) The notation "R" means number right; "W" means wrong, i. e. attempted but answered incorrectly. "T" means True, "F" means False.
- (d) Part scores should be recapitulated on Page 3 of the examination.
- (e) For part "A" it is necessary to have the scoring done by someone familiar with lettering.
- (f) No negative scores are given; the least score is zero (0).

NORMS:

Norms for the tentative edition are not yet available.

Department of Engineering Drawing
SCHOOL OF MINES AND METALLURGY
University of Missouri
Rolla

PLACEMENT EXAMINATION IN GENERAL ENGINEERING DRAWING, UNIT G. E. D.—2

(Aptitude)

Revised Edition

GENERAL DIRECTIONS

[illegible] not write anything until told to do so.
When the signal is given, begin to work on Part A.
Do not write on any part until told to do so.
At the beginning of each part will be found directions for that part.
Follow the directions carefully, but **do not ask questions.**

PART A (Items Nos. 1 to 48 inclusive)

Directions: It is desired that you shall PRINT, AND NOT WRITE, the answers or information asked for in the following. You have 5 minutes for Part A.

1. **Print** your surname first, follow with given name and initial ....
2. For what course are you enrolled at M. S. M.? ....
3. Have you ever had a course in mechanical drawing? If so, where was the course taken, and what was its nature?

....

....

4. Have you had a course in plane geometry? ....
5. Have you had a course in solid geometry? ....
6. Have you been employed at any time heretofore in doing practical work in drafting or in engineering out of school? If so, please give essential details concisely.

....

....

....

7. Have you had a course in manual training? ....
8. Have you had any course in freehand drawing or sketching? ....
9. Do you draw faces, cartoons, or make posters or fancy lettering of any sort? ....
10. Have you any defects of eyesight, or are you troubled with weak eyes or any other ocular ailment that would prevent prolonged use of the eyes on detail work?

....

....

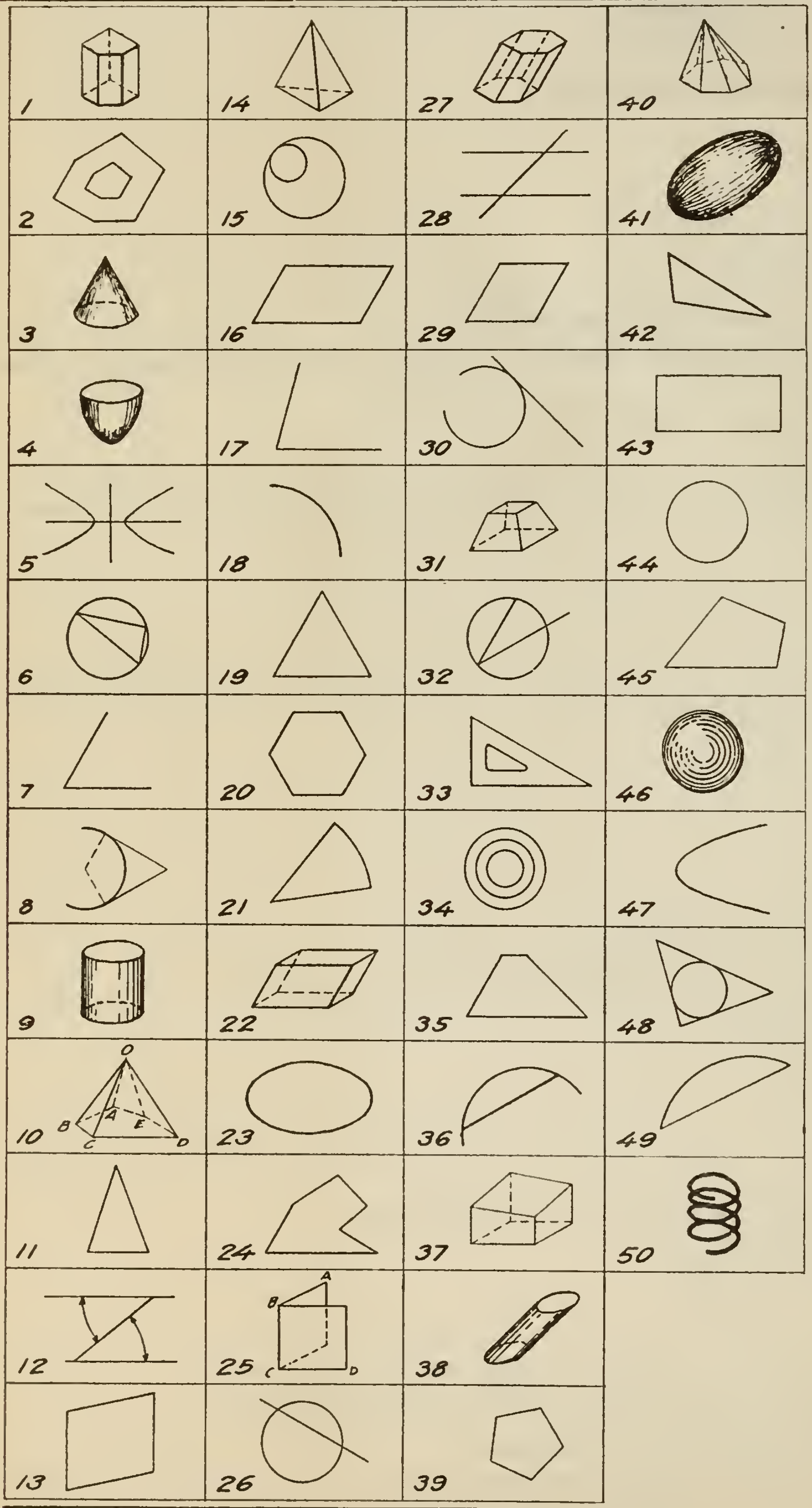
11. Please check from the following statements that one, (or the two or three) that most closely sets forth your opinions:
    (a) ....I am taking engineering drawing because it is a required course.
    (b) ....I am taking drawing because I like it.
    (c) ....I have no special liking for drawing.
    (d) ....I dislike drawing.
    (e) ....I like to plan machines, structures, apparatus, and need drawing to help me do it.
    (f) ....I aim to become an engineer, and need to know drafting in that kind of work.
    (g) ....I wish to qualify myself to fill a position as draftsman.

Possible Score, Part A:	Method of Scoring:	Actual Score, Part A:
Maximum 48 Minimum 0 Lettering 25 Responses 23	(See key)	Lettering (Items 1-25) .... Responses (Items 26-48) .... Total Part Score ....

PART 1

Directions: On the following page are representations of various geometric entities, such as plane curves and figures, surfaces, and solids, which are studied in geometry, and which are made extensive use of both in engineering and in engineering drawing. Each figure is numbered. The column of words contains the names of all the figures, lines, curves, surfaces, and solids shown. On the dotted line preceding each word, write in the number of the figure of which that word is the name, or to which it refers. DO NOT GUESS. If you are reasonably certain that a name and figure match, then mark it—otherwise, leave it alone. Each name correctly numbered will score one point for you. Incorrectly numbered names will take one point away.

First look at the name, then find the figure. Cross out each figure as you find its name. You have 15 minutes for this part.



		Item No.
....	Plane	49
....	Circumscribed triangle	50
....	Transversal	[illegible]
....	Similar polygons	52
....	Equal tangents	53
....	Dihedral angle	54
....	Parallelopiped	55
....	Ellipse	56
....	Rhombus	57
....	Cone	58
....	Scalene triangle	59
....	Drawing triangle	60
....	Right cylinder	61
....	Heptagonal pyramid	62
....	Concentric circles	63
....	Paraboloid	64
....	Angle of 75 degrees	65
....	Frustum of pyramid	66
....	Rectangle	67
....	Right prism	68
....	Pentagon	69
....	Tetrahedron	70
....	Alternate interior angles	71
....	Hyperbola	72
....	Circular sector	73
....	Oblique hexagonal prism	74
....	Secant line	75
....	Parabola	76
....	Segment of circle	77
....	Equiangular triangle	78
....	Trapezoid	79
....	Tangent line	80
....	Inscribed triangle	81
....	Chord	82
....	Nonrectangular parallelogram	83
....	Truncated prism	84
....	Trapezium	85
....	Circle	86
....	Internally tangent circles	87
....	Hexagon	88
....	Irregular polygons	89
....	Sphere	90
....	Inscribed angle	91
....	Helix	[illegible]
....	Isosceles triangle	93
....	Polyhedral angle	94
....	Oblique cylinder	95
....	Spheroid (ellipsoid)	96
....	Quadrant	97
....	Angle of 60 degrees	98

Possible Score, Part 1:	Character of Responses:			Method of Scoring:	Actual Score, Part 1:
Maximum, 50	No. Rights	Wrongs	Omitted	"Rights—Wrongs"	
Minimum, 0	....	....	....		....

PART 2

Directions: Read these statements and encircle "T", at the right of each statement, with a small circle if you think it is true. Encircle "F" if you think it is false. Your score will be based upon these signs only; don't waste time writing anything else. First go through the list quickly and mark all that you know for certain at once; then go back and study out the harder ones.

Don't guess! A wrong response counts heavily against you. Omit statements about which you know nothing.

A statement is true only if every part of it is true; a statement is false if any part of it is untrue. You have 15 minutes for this part.

Item No.		
99. A fine silk thread is a geometric line	T	F
The end of a very small wire is a good example of a geometric point	T	F
101. Part of a straight line is called a segment of that line	T	F
102. Solid geometry treats only of figures that do not lie wholly in the same plane	T	F
103. Two lines which intersect are not in the same plane	T	F
104. A circle is a curvilinear figure	T	F
105. The opening between two straight lines drawn from a point is called a straight angle	T	F
106. A line drawn through a circle, terminated at each end by the circle, is a diameter	T	F
107. When a right or obtuse angle is bisected the two resulting angles are acute	T	F
108. If we bisect a reflex angle, we always form two obtuse angles	T	F
109. If two adjacent angles are equal, their sum is equal to two right angles	T	F
110. Vertical angles are always equal and adjacent angles	T	F
111. All the interior angles of an isosceles triangle are acute	T	F
112. The angles of an equiangular triangle are equal to the angles of every other equiangular triangle	T	F
113. No polygon can be cut in more than two places by one straight line	T	F
114. Two triangles are equal if the three sides of one are equal to three sides of the other	T	F
115. Two right triangles are congruent if any two sides of one are equal to two sides of the other	T	F
116. A straight line parallel to two straight lines is in the plane of those two lines	T	F
117. If two parallel lines are cut by a transversal the two interior angles on the same side of the transversal are complimentary	T	F
118. When two lines are cut by a transversal, if the exterior-interior angles are supplementary the lines are parallel	T	F
119. An exterior angle of a triangle is larger than either of the opposite interior angles	T	F
120. A diagonal is a straight line joining any two vertices of any figure	T	F
121. Two angles whose sides are parallel each to each are equal	T	F
If the opposite sides of a quadrilateral are equal, the figure is a rectangle	T	F
123. The diagonals of a quadrilateral bisect each other	T	F
124. The line which joins the midpoints of two sides of a triangle is parallel to the third side, and is equal to one-half the third side	T	F

Item No.		
125. No concave polygon is equiangular	T	F
126. Each interior angle of a regular polygon of n sides is equal to 2 (n-2) right angles/n	T	F
127. The sum of the exterior angles of a polygon, made by producing each of its sides in succession is equal to four straight angles	T	F
128. The proof of a locus problem is complete when it has been shown that any point in the supposed locus satisfies the conditions laid down in the problem	T	F
129. In an isosceles triangle the medians drawn to the equal sides are equal	T	F
130. The bisectors of the equal angles of an isosceles triangle form, together with the base, an isosceles triangle	T	F
131. The bisectors of two consecutive angles of a parallelogram are perpendicular to each other	T	F
132. If two straight lines intersect at right angles, any point in either is equidistant from the extremities of the other	T	F
133. If either diagonal of a parallelogram bisects one of the angles, the sides of the parallelogram are all equal	T	F
134. Every parallelogram inscribed in a circle is a square or a rhombus	T	F
135. The sum of the distances of any point from the three vertices of a triangle is greater than one-half the sum of the sides	T	F
136. To construct a triangle with sides two inches, three inches, and six inches is called a *determinate* problem	T	F
137. The lines joining the midpoints of the consecutive sides of any quadrilateral form a square	T	F
138. If the diagonals of a parallelogram are equal all the angles of the parallelogram are equal	T	F
139. If the diagonals of a parallelogram are equal the parallelogram is a square	T	F
140. A line through the center that bisects any chord bisects the arc subtended by that chord	T	F
141. All the lines bisecting a chord coincide	T	F
142. If two chords intersect and make equal angles with the diameter through their point of intersection, these chords are equal	T	F
143. All equal chords of a circle are tangent to a concentric circle	T	F
144. If two circles intersect, the line of centers is parallel to their common chord	T	F
145. Any trapezoid may be inscribed in a circle	T	F
146. A portion of a plane bounded by an arc of a circle and its chord is called a sector of the circle	T	F
147. In plane geometry we have limiting forms as well as limiting values	T	F
148. In the same circle or in equal circles two central angles have the same ratio as their intercepted arcs whether the arcs are commensurable or not	T	F

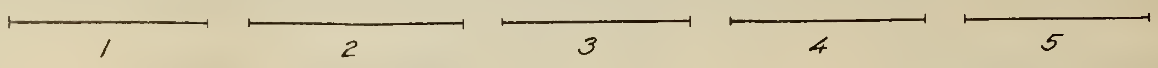
Possible Score, Part 2:	Character of Responses:			Method of Scoring:	Actual Score, Part 2:
Maximum, 25 Minimum, 0	No. Rights	Wrongs	Omitted	$\frac{\text{"Rights—Wrongs"}}{2}$	

PART 3

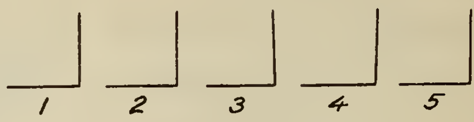
Directions: Carefully examine the different figures shown, choose that one which nearest fullfils the conditions stated, and write the number belonging to it as your answer on the dotted line at the right margin of the page. You have 10 minutes for this part.

Item No. **Answers**

149. One of the five lines shown just below is, with small error, exactly one inch long. ....

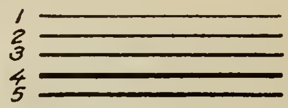


150. Which of the five angles shown, is more nearly a right angle than the others? ....

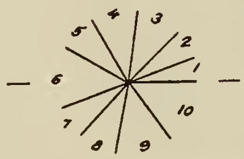


151. Which of the five circles shown is more nearly an eighth of an inch in diameter than the others? ....

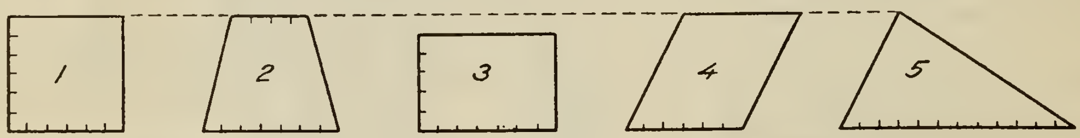
152. Which of the five lines has a width nearest 1/40 inch? ....



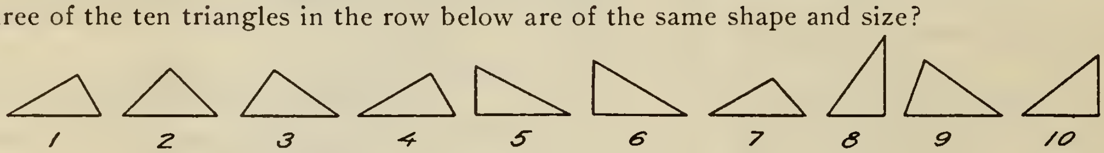
153. Which of the several angles is almost exactly 30°? ....



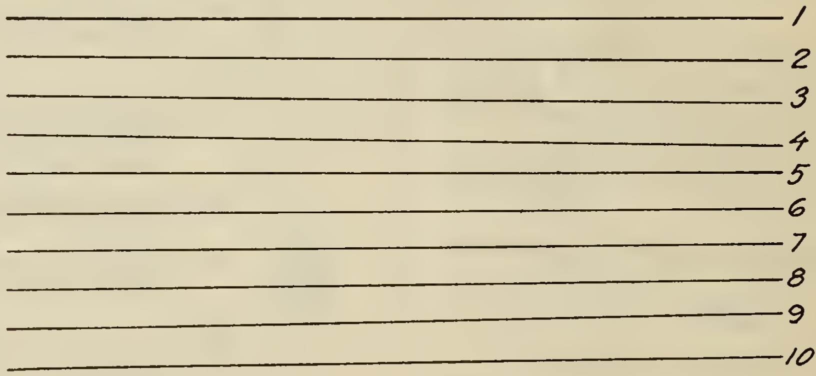
154. Three of the five figures shown below have exactly the same area. The areas of the other two differ both from each other and from that of all the other figures. Select the three equivalent areas. ....



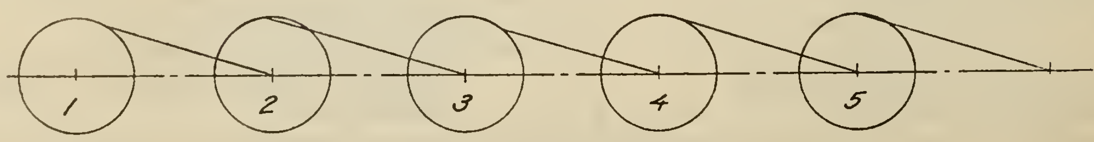
155. Which three of the ten triangles in the row below are of the same shape and size? ....



156. Which two of the ten lines shown are most nearly parallel? ....



157. In which one of the five figures below does the straight line most closely meet the circle at the point of tangency? ....



Possible Score, Part 3:	Character of Responses: No. Rights	Wrongs	Omitted	Method of Scoring:	Actual Score, Part 3:
Maximum, 9 Minimum, 0	....	....	....	"Rights"	....

PART 4

Directions: Answer the questions as follows: On the dotted line following the questions write the number of the bracketed passage which contains the correct answer.

Read the passage as often as necessary.

The first question is already answered correctly. A "10" is placed after Question 1 because bracket 10 in the passage contains the correct answer. Similarly, the answer to Question 2 is found in some one or two of the remaining brackets. You have 15 minutes for this part.

The engineer adapts the materials and controls the forces of nature for the convenience and comfort of mankind.[1] He does this by designing and building structures of many kinds:[2] machines, buildings, bridges, factories, tools, tunnels, canals, roads, railways, ships, instruments, apparatus, and public works in general.

Progress in engineering work of any kind depends upon an intimate knowledge of mechanical drafting[3] as the language of the engineering world.[4] There are two things which a designer, inventor, or builder must be able to do: first, he must be able to visualize,[5] or to see clearly in his mind's eye what an object looks like without actually having the object; second, he must be able to describe it so that it could be built.[6] A picture[7] can be made which would show, just as a photograph would do, the general appearance of the object, but it would not show the exact forms and relations of the parts of the object.[8] It would show it as it appears, and not as it really is. If we look down at the object from directly above we obtain a view showing the exact shape of the base and the outline of the other parts as seen from above.[9] This is called a top view, or plan. This view does not tell us the height of the object, so it is necessary to take another view (an elevation)[10] from a position directly in front or else (a profile) from the left or right side.

In this way either a front view or side view to show the height[11] is added. Often both front view and side view, in addition to top view, are needed to describe the object. The three views taken together completely define the shapes of all the parts of the object and their exact relations to each other.[12] The principle of representing an object by different views, as just described,[13] is called Orthographic Projection,[14] and is the basis of all kinds of industrial drawing.

Engineering Drawing has for its purpose the exact description of both the shape and the size of structures.[15] Engineering drawing thus makes use of the methods of Geometry[16] and, in addition, is concerned with placing dimensions, explanatory notes, and symbols,[17] on drawings. The question of time or efficiency,[18] enters into all engineering work and should be considered in studying engineering drawing. Accuracy and neatness[19] not only save time but are absolute essentials if worth while progress is to be made.

(Example) The front view of an object is called ..10..

Answers:

Item No.

158. A plan is ....
159. What two things must a designer be able to do? ....
160. Orthographic projection is defined as ....
161. Four things are prime requisites in engineering and drafting, namely: ....
162. Why is a photograph not suited to convey instructions to workmen? ....
163. Plan, elevation, and profile taken together convey an exact impression of ....
164. What is mechanical drafting? ....
165. In engineering drawing use is made of four things namely ....
166. In general what does the engineer do? ....
167. A primary purpose of the profile view is ....
168. With what may an engineer supplement his mechanical drawing? ....
169. Upon what does progress in engineering work depend? ....
170. The purpose of engineering drawing is ....
171. The basis of all kinds of industrial drawing is ....
172. How does the Engineer accomplish his work? ....

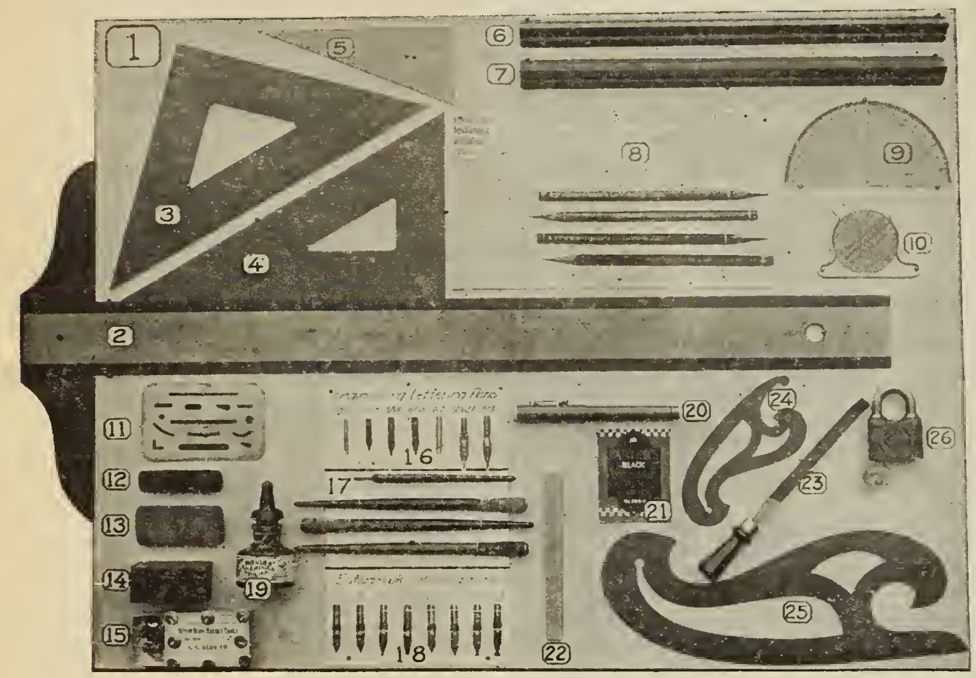
Possible Score, Part 4:	Character of Responses: No. Rights	Wrongs	Omitted	Method of Scoring:	Actual Score, Part 4:
Maximum, 15 Minimum, 0	....	....	....	"Rights"	....

PART 5

A. **Directions:** In Plate 1 are half-tone cuts of the tools and equipment most often used by the draftsman. Beside each article is placed a number. In a column at the right of the page are the names of these articles. Examine the pictures, after which place the proper number of each article in front of its name in the column at the right. You have 10 minutes for this part.

Example: ......6...... Architect's Scale

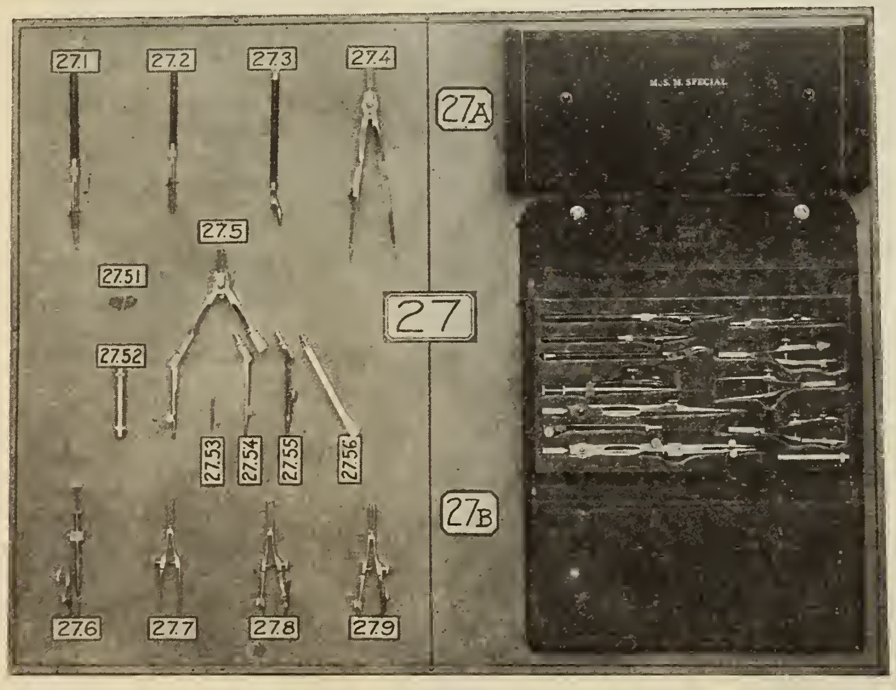
PLATE 1



		Item No.
....	Ames Lettering Instrument	173
....	Drawing Board	174
....	Metal erasing shield	175
....	Triangle 45°	176
....	Tack lifter	177
....	Yale padlock	178
....	Civil Engineer's Scale	179
....	Triangle 30x60°	180
....	Higgin's India Ink	181
....	11″ French Curve	182
....	T square	183
....	5″ French Curve	184
....	Protractor	185
....	Drawing pencils	186
....	Slope triangle	187

B. **Directions:** In Plate 2 are half-tone cuts of the assortment of case drawing instruments most often used by the draftsman. Beside each instrument is placed a number. In the column at the right of the page are the names of all these instruments. Examine the pictures after which place the proper number of each instrument in front of its name in the column at the right.

PLATE 2



....	4½″ Ruling Pen	188
....	Adjusting key	189
....	Drop spring bow pen	190
....	Dividers	191
....	Detachable pencil leg	192
....	5½″ Ruling Pen	193
....	Compasses	194
....	Detachable pen leg	195
....	Bow pencil	196
....	Lengthening bar	197
....	Contour pen	198
....	Extra steel point	199
....	Bow pen	200
....	Bow dividers	201
....	Tube of extra points and leads	202

Possible Score, Part 5:	Character of Responses:			Method of Scoring:	Actual Score, Part 5:
Maximum, 15 Minimum, 0	No. Rights	Wrongs	Omitted	"Rights" 2	....

PART 6

A.—Directions: Read the following paragraph, then carefully examine the statements beneath it. Every statement is to be compared with the material in the paragraph. If the statement is true, encircle the "T" after it. If the statement is false, encircle the "F" after it.

DO NOT GUESS. You have 15 minutes for this part.

The complete description of a machine or structure requires the use of the graphical language to describe shapes, and the written language to tell sizes, methods of making, kind of materials, and other notes. The "written language" as used on drawings is always in the form of lettering and not in script writing. Simple freehand lettering perfectly legible and quickly made is an important part of modern engineering drawings. The standard form of letter used on working drawings is the style known as "single-stroke Gothic." The term "single stroke" means that the width of the stem of the letter is the width of the stroke of the pen. There are two varieties, vertical and inclined. Vertical strokes are all made downward, and horizontal strokes are from left to right. Guide lines, ruled lightly with a sharp pencil, should always be drawn for the tops and bottoms of each line of letters. Lettering is not mechanical drawing. A certain degree of expertness in lettering is assumed to be one of the qualifications of present-day engineers.

Item No.			
203.	Numerous signs and symbols are used on engineering drawings in place of explanatory notes to denote finish, kind of material, and various other information	T	F
204.	Mechanical drawing, of itself, is purely a language of form and relations of parts—not of size	T	F
205.	Miscellaneous notes on drawings are always printed in script	T	F
206.	In engineering lettering, each character requires but a single stroke of the pen to make it complete	T	F
207.	Guide lines are required for beginners in lettering—the practical draftsman can dispense with them	T	F
208.	Denotation of size is a major function of lettering on engineering drawings	T	F
209.	Lettering is acceptable if it can be deciphered at all, even though it is not of the best quality	T	F
210.	Line drawing for form, plus lettering for size, etc., constitute mechanical drawing	T	F
211.	There are more opportunities for an engineer who can letter well than for one who cannot	T	F
212.	Modern engineering lettering is always executed in rapid freehand style	T	F

B.—Directions. Carefully read the statements just beneath, then examine each group of letters enclosed by a bracket in the sample of engineering lettering at bottom of page. By means of the capital letters taken from the brackets in the paragraph of rules indicate what principle is violated in each bracketed group of the engineering lettering, placing the correct letter on the appropriate dotted line along the right margin of the page.

Good lettering requires consideration of the following things:

The $\underbrace{\text{rule of stability}}_{A}$ requires that the irregular white surfaces enclosed by black lines appear to be balanced in each letter. Bars in such letters as A and B must be drawn nearer to the top than to the bottom, and letters and figures such as S, Z, and 3 must be drawn smaller at the top to overcome optical illusion. The $\underbrace{\text{principle of balance}}_{B}$ requires that the area of white spaces between adjacent letters and successive words shall be approximately equal to each other and appear the same. By good $\underbrace{\text{composition}}_{C}$ is meant the selection of appropriate $\underbrace{\text{styles}}_{D}$ and $\underbrace{\text{sizes of letters}}_{E}$ and that careful $\underbrace{\text{spacing of letters}}_{F}$ in words and $\underbrace{\text{spacing of words in sentences}}_{G}$ which compels the approval of the readers because of the ease with which it is read and the $\underbrace{\text{general pleasing effect it has.}}_{H}$ $\underbrace{\text{Improperly formed letters}}_{I}$ and $\underbrace{\text{letters having varying widths of stroke}}_{J}$ contribute to the bad appearance of lettering. $\underbrace{\text{Non-uniformity in slope}}_{K}$ in letter strokes gives bad appearance to composition. $\underbrace{\text{Capitals and small letters should never be mixed in the body of a word.}}_{L}$ $\underbrace{\text{Blots,}}_{M}$ and $\underbrace{\text{letters over or under size}}_{N}$ should be avoided. Letters and words should be made to $\underbrace{\text{follow horizontal guide lines.}}_{O}$

Bracket No.	Item No.
1.	213
2.	214
3.	215
4.	216
5.	217
6.	218
7.	219
8.	220
9.	221
10.	222
11.	223
12.	224
13.	225

$\underbrace{\text{So far}}_{1}$ as its $\underbrace{\text{appearance is concerned}}_{2}$ $\underbrace{\text{there is no part}}_{3}$ $\underbrace{\text{of a dro}}_{4}$
ing $\underbrace{\text{so important}}_{5}$ $\underbrace{\text{a sthel ettering.}}_{6}$ $\underbrace{\text{A good drawing may be ruined}}_{7}$
$\underbrace{\text{not only in appearance}}_{8}$ $\underbrace{\text{BUT IN USEFULNESS}}_{9}$ $\underbrace{\text{by lettering done}}_{10}$
$\underbrace{\text{IGNORANTLY OR CARELESSLY}}_{11}$ $\underbrace{\text{as illegible figures}}_{12}$ $\underbrace{\text{are very apt to cause mistakes in the work.}}_{13}$

Possible Score, Part 6:	Character of Responses:	Method of Scoring:	Actual Score, Part 6:	
A: Maximum, 10; Minimum, 0	A: Rights........; Wrongs........; Omit........	A: "Rights—Wrongs"	A........	ALL:
B: Maximum, 13; Minimum, 0	B: Rights........; Wrongs........; Omit........	B: "Rights"	B........	

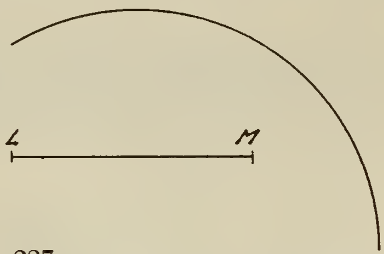
PART 7

Directions: Complete the following geometric constructions making use of nothing but the pencil compass, a drawing pencil, and a straight edge. Under no circumstances must you use scale, triangles, or other instruments. Leave on the page all construction lines that you draw. You have 15 minutes for this part.

1. Bisect line A-B

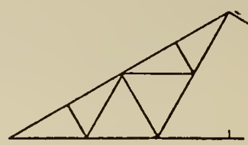
226

6. Find center of arc. L-M is radius.



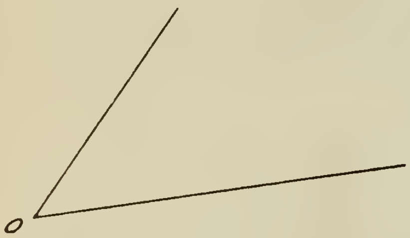
227

11. Complete other half of figure.



228

2. Bisect ∡ O.

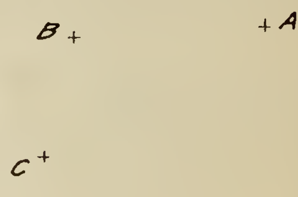


229

7. Construct hexagon with line R-S as one side.

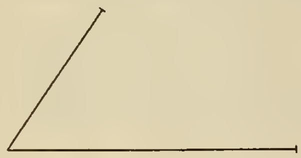
230

12. Draw a circle through A, B, & C.



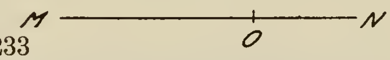
231

3. Draw remainder of parallelogram of which two sides are shown.



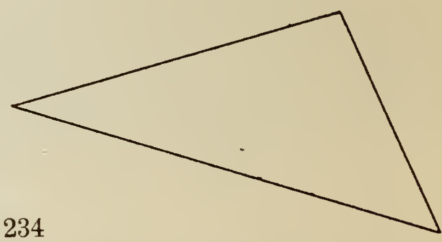
232

8. Erect a ⊥ to M-N at O.



233

13. Inscribe a circle within the triangle.

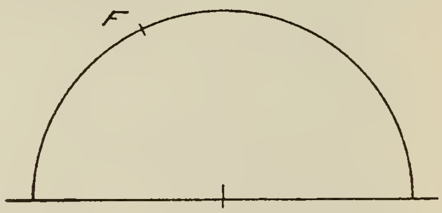


234

4. Copy angle O.

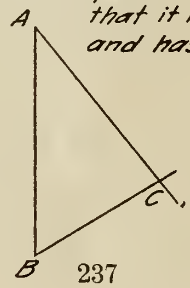
235

9. Construct a right angle at F.



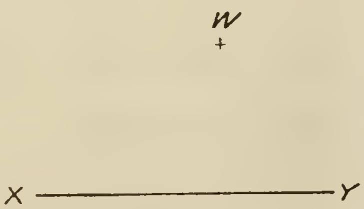
236

14. Complete Δ CDE to right of C so that it is similar to ABC and has $\frac{1}{4}$ area ABC.



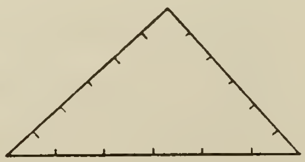
237

5. Drop a ⊥ to X-Y from W.



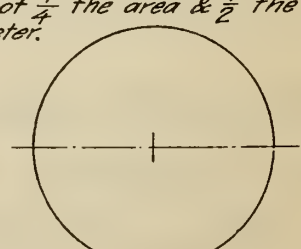
8-26-27. 238

10. Draw six lines, any one of which will exactly divide the area of the triangle into halves.



239

15. Within this circle draw another circle of $\frac{1}{4}$ the area & $\frac{1}{2}$ the perimeter.



240 #

Possible Score, Part 7:	Character of Responses:			Method of Scoring:	Actual Score, Part 7:
Maximum, 15 Minimum, 0	No. Rights	Wrongs	Omits	"Rights"	

Published by the
Public School Publishing Co.
Bloomington, Illinois
Printed in U. S. A.

TEACHER'S MANUAL

FOR

A SERIES OF STANDARD TESTS IN FUNDAMENTAL MECHANICAL DRAWING

By ALEX. J. BADGER,
Instructor, Mechanical and Architectural Drawing, Lincoln High School, Los Angeles, California.

Subjects

Test 1—Use of Tools—Linework—Dimensioning—Lettering.

Test 2—Projection, including Sections and Auxiliary Views.

Test 3—Pictorial Drawing (Isometric—Cabinet—Oblique).

In using the accompanying tests, the teacher of mechanical drawing should have a clear understanding of their scope. First, they are limited to fundamentals. No advanced problems are used, since the grading of such problems would necessarily involve the subjective judgment of the teacher and thereby destroy the objective value of the tests. Secondly, these are tests of what the pupil knows about the phases of drawing covered rather than a test of his drawing ability measured in terms of neatness, accuracy, lettering, etc. After all, the daily routine drawing work provides a constant test of that sort, and these are intended as general check-ups on the pupil's accumulated knowledge of the subject.

The subject matter has been divided into three sections rather than included in one general test, since the order of presenting the various subjects covered varies in the different schools.

General Instructions for Giving

The instructions for giving are given on the front-page of each test.

Distribute the tests to the students, and have them fill in the blanks for name, date, etc., at the top of the front page. Then read aloud the general directions on the front page of the test booklet.

There is no time limit on any of the tests, but the booklets should be collected as soon as all but the slowest two or three students have finished.

General Instructions for Scoring

The answers for each test are given on the following pages. It is suggested that the teacher take an unused test paper, mark the correct answers with a colored pencil, and use this as a guide in scoring.

More accurate and rapid results are obtained if the teacher completes one page of all the papers before proceeding to the next page; that is, first score page 1 of all papers, then page 2 of all papers, etc.

Any clear indication of the answer is acceptable, even though it may not be strictly in accordance with the directions. For example, if a student draws a ring around the correct answer instead of underlining it, give him full credit for the exercise. In case of doubt, no credit is to be given.

Please note the credit or value to be given each exercise, as indicated in the scoring key. For example, in Exercise No. 4 of Test 1, each correct answer counts $\frac{1}{4}$. In Exercises 21 to 25 of Test 2, the score of 5 is given for the proper indication, but 1 is taken away from this score for each incorrect indication. In no case is a negative score to be given for any part. If the number of points to be subtracted because of incorrect answers exceeds the credit to be given for correct answers, the score is zero for that particular exercise or group of exercises, as the case may be. *This part of the scoring must be carefully followed.* For the sake of accuracy and speed in computing the pupil's score, it is advisable to write the score for each part in the margin as that part is scored.

After all pages have been scored, add the numbers thus written in the margin and enter the sum in the blank for "Pupil's Score" at the end of the test. Please note that for Test 1, the pupil's score is multiplied by $1\frac{1}{3}$ in order to obtain his final score; that for Test 2, his score is multiplied by $2\frac{1}{2}$; and that for Test 3, his score is multiplied by $3\frac{1}{3}$. After the final score has been determined, transfer the score to the space provided therefor in the upper right-hand corner of the front page of the test booklet.

After all the test papers have been scored, record the scores on the class record sheet and determine the class median as directed thereon.

Instructions for Scoring Test 1

Exercise Numbers	
1 to 25	**Multiple-choice Test:** Score 1 for each exercise with correct underlining. If a pupil marks a correct answer and also one or more incorrect answers, count the score zero. For example, if in Exercise 1 he should correctly underline "left" but should also underline "right," his score for Exercise 1 would be zero. In Exercises 4, 5, 10, 16, and 17, where there is more than one part to be underlined, each part has a fractional value as indicated in the score column at the left of the scoring key. For instance, in No. 4, if three parts are correctly answered and one incorrectly answered, the score for No. 4 is $\frac{3}{4}$.
26 to 33	**Size of Angle Test:** Score 1 for each angle filled in with the correct number of degrees. Highest possible score is 8.
34 to 38	**Weight of Line Test:** Score 1 for each proper underlining, but take off $\frac{1}{2}$ point from this score for each incorrect indication. Do not give a negative score.
39	**Best Arrowhead Test:** Score 1 for correct indication. If two or more arrows are marked, the score is zero.
40 to 75	**Best Letter and Figure Form Test:** Score 1 for each correct indication. If two or more specimens of the **same letter or figure** are checked, no credit is to be given for that particular letter or figure, even though one indication may be correct.

Obtain final score for Test 1 by multiplying pupil's actual test score by $1\frac{1}{3}$.

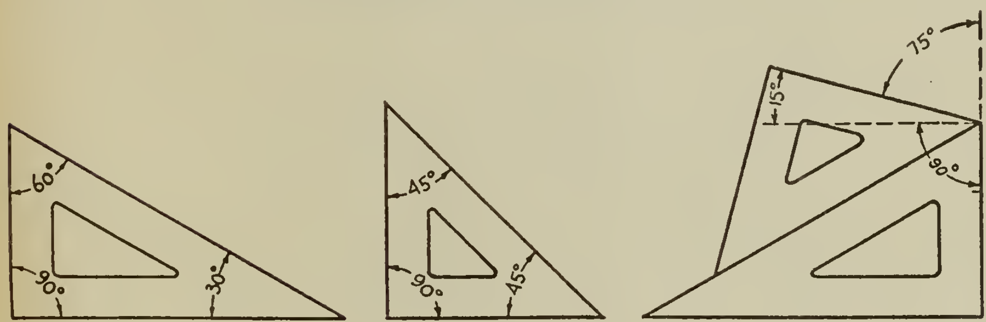
Answer key for Test 1

Use of Tools—Linework—Dimensioning—Lettering

Score Value	*Exercise Number*	*Correct Answer*
(1)	1.	left
(1)	2.	upper
(1)	3.	left
(¼)	4.	4H—hard
(¼)		2B—soft
(¼)		HB—medium
(¼)		4H
(½)	5.	should not
(½)		should
(1)	6.	away from you
(1)	7.	should
(1)	8.	light
(1)	9.	never be inked
(½)	10.	′—feet
(½)		″—inches
(1)	11.	light
(1)	12.	should not

Score Value	*Exercise Number*	*Correct Answer*
(1)	13.	a little past
(1)	14.	should read
(1)	15.	lower and right
(½)	16.	horizontal
(½)		even with
(½)	17.	radius
(½)		diameter
(1)	18.	should not
(1)	19.	should not
(1)	20.	center
(1)	21.	need not be
(1)	22.	which tells the most about the shape of the object
(1)	23.	between views
(1)	24.	should never cross
(1)	25.	about ¼ inch of ink

(8) 26–33. Score 1 for each angle filled in with correct number of degrees. Highest possible score is 8.



(5) 34–38. Score 1 for each proper underlining, but take off ½ point from this score for each incorrect indication. Do not give a negative score.

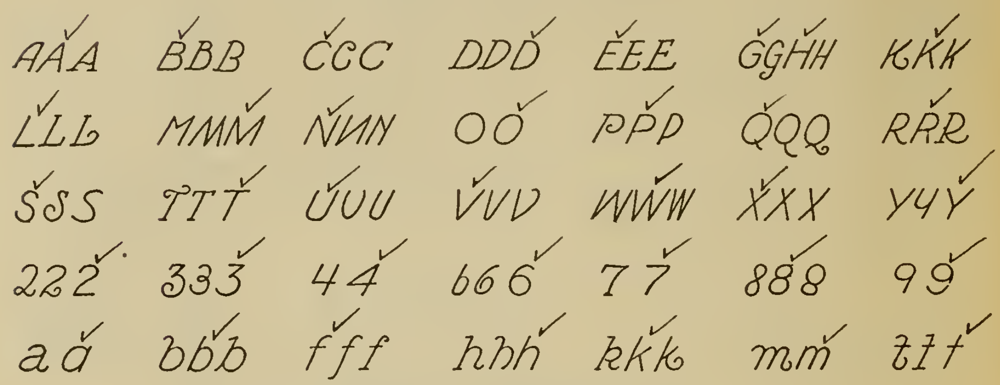
Border line   Main line   Dimension line   Extension line   Center line

Border line   Main line   Dimension line   Extension line   Center line

Border line   Main line   Dimension line   Extension line   Center line

Score Value	*Exercise Number*	*Correct Answer*
(1)	39.	Score 1 for correct indication. If two or more arrows are marked, the score is zero.

(36)	40–75.	Score 1 for each correct indication. If two or more specimens of the **same letter or figure** are checked, no credit is to be given for that particular letter or figure, even though one indication may be correct.



Instructions for Scoring Test 2

Exercise Numbers	
1 to 10	**Multiple-choice Test:** Score 1 for each exercise with correct underlining. If a pupil marks a correct answer and also one or more incorrect answers, count the score zero. For example, if in Exercise 1 he should correctly underline "in two or more views placed in a certain relation to each other" but should also underline "by showing a picture of it," his score for Exercise 1 would be zero.
11 to 20	**Proper Relationship of Views Test:** Score 2 for each correct indication, but take off 1 from this score for each incorrect indication. Do not give a negative score.
21 to 25	**Correct Projection Test:** Score 5 for the proper indication, but take off 1 from this score for each incorrect indication. Do not give a negative score.
26 to 29	**Correct Projection Test:** Score 4 for the proper indication, but take off 1 from this score for each incorrect indication. Do not give a negative score.
30 to 35	**Missing Line Test:** Score 1 for each line correctly placed and correctly drawn as full line or dotted line as indicated in the answer key. If more than six lines are drawn, take off 1 for each extra line. Do not give a negative score.
36 to 38	**Correct Section View Test:** Score 3 for the proper indication, but take off 1 from this score for each incorrect indication. Do not give a negative score.
39 to 40	**Recognition of Auxiliary Views Test:** Score 1 for each proper indication, but take off 1 from this score for each incorrect indication. Do not give a negative score.

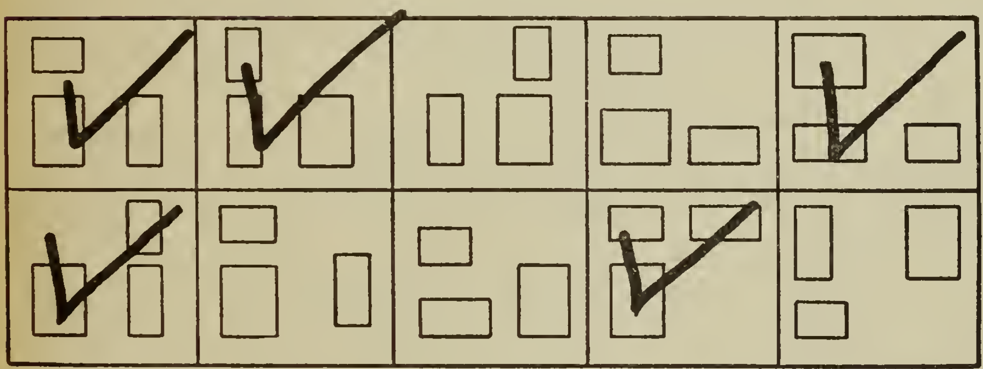
Obtain final score for Test 2 by multiplying pupil's actual test score by 2½.

Answer key for Test 2

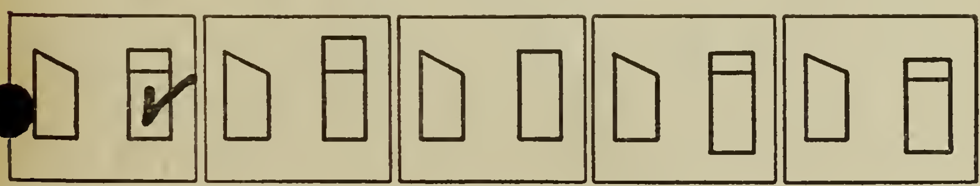
Projection, including Sections and Auxiliary Views

Score Value	*Exercise Number*	*Correct Answer*
(1)	1.	in two or more views placed in a certain relation to each other
(1)	2.	it is the only method in which the exact forms and relations of the parts of the object can be shown
(1)	3.	a view showing it as though it had been cut in two or more parts and the interior exposed
(1)	4.	make the construction of the object more easily understood
(1)	5.	which has been cut
(1)	6.	45°
(1)	7.	fine
(1)	8.	an extra view which helps you to understand the shape of the object
(1)	9.	in its true shape
(1)	10.	perpendicular to it

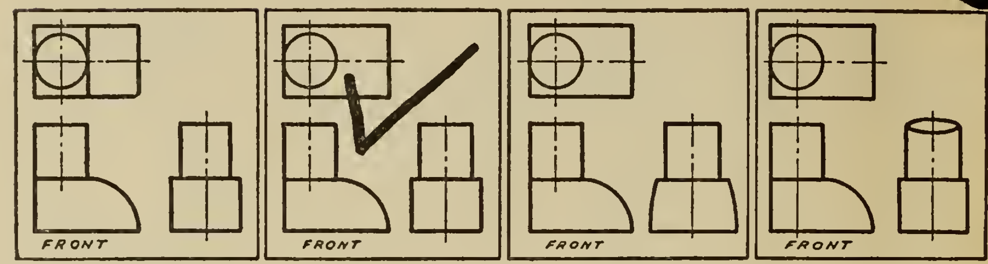
(10) 11–20. Score 2 for each proper indication, but take off 1 from this score for each incorrect indication. Do not give a negative score.



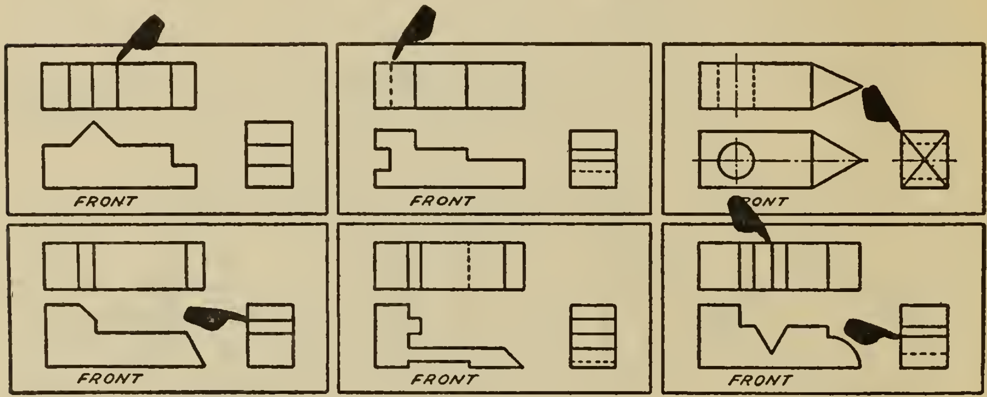
(5) 21–25. Score 5 for the proper indication, but take off 1 from this score for each incorrect indication. Do not give a negative score.



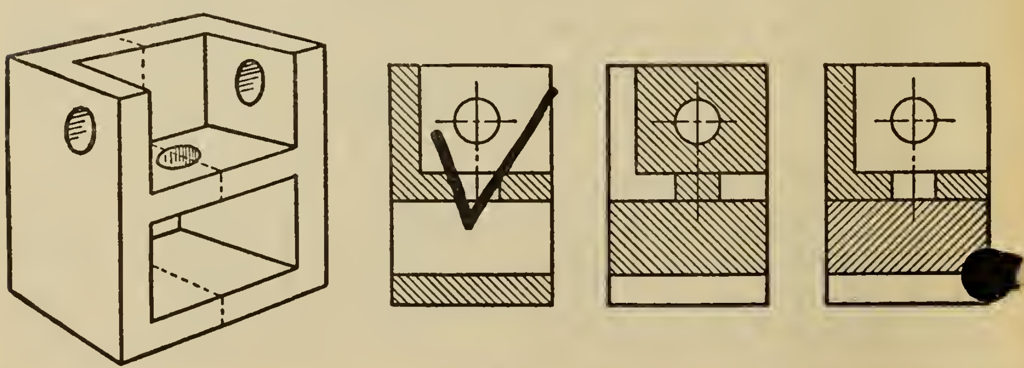
Score Value	*Exercise Number*	*Correct Answer*
(4)	26–29.	Score 4 for the proper indication, but take off 1 from this score for each incorrect indication. Do not give a negative score.



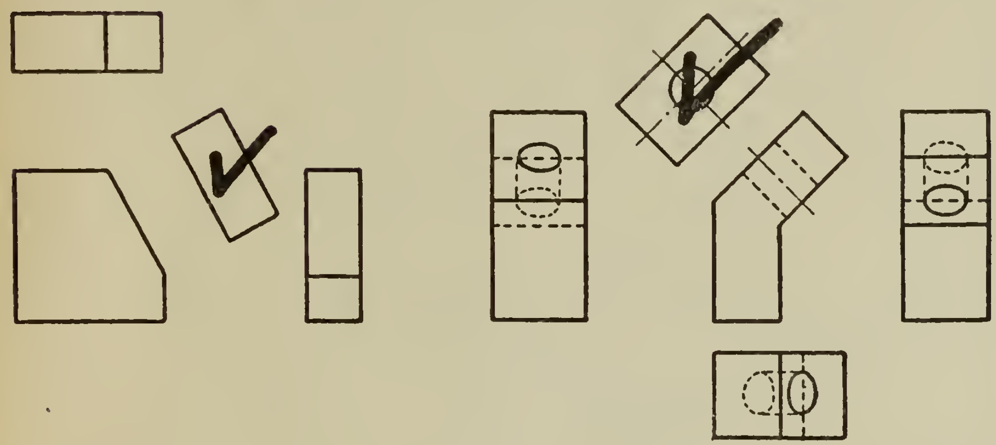
(6)	30–35.	Score 1 for each line correctly placed and correctly drawn as full line or dotted line as indicated in the answer key. If more than six lines are drawn, take off 1 for each extra line. Do not give a negative score. (The hands in the answer key are not, of course, a part of the required answer, but are merely inserted in the scoring key to point to the lines which the pupils should insert.)



(3)	36–38.	Score 3 for the proper indication, but take off 1 from this score for each incorrect indication. Do not give a negative score.



Score Value	*Exercise Number*	*Correct Answer*
(2)	39–40.	Score 1 for each proper indication, but take off 1 from this score for each incorrect indication. Do not give a negative score.



Instructions for Scoring Test 3

Exercise Numbers	
1 to 16	**Multiple-choice Test:** Score 1 for each exercise with correct underlining. If a pupil marks a correct answer and also one or more incorrect answers, count the score zero. For example, if in Exercise 1 he should correctly underline "somewhat as it appears to the eye" but should also underline "in two or more views," his score for Exercise 1 would be zero. In Exercises 6, 7, 10, and 13, where there is more than one part to be underlined, each part has a fractional value as indicated in the score column at the left of the scoring key. For instance, in No. 10, if two parts are correctly answered and one incorrectly answered, the score for No. 10 is $\frac{2}{3}$.
17	**Recognition of Isometric Axes Test:** Score 1 for correct answer.
18 to 27	**Recognition of Isometric Lines Test:** Score 1 for each isometric line checked, and also score 1 for each non-isometric line **not** checked. Highest possible score is 10.
28 to 30	**Recognition of Isometric, Oblique, and Cabinet Drawings Test:** Score 1 for each correct indication.

Obtain final score for Test 3 by multiplying pupil's actual test score by $3\frac{1}{3}$.

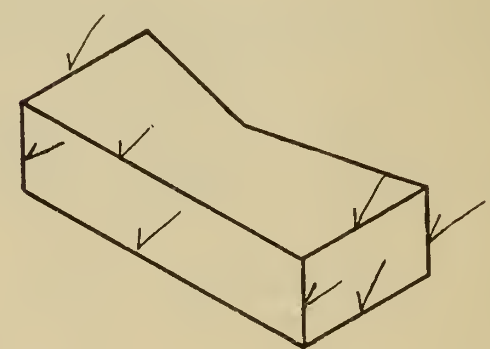
Answer key for Test 3

Pictorial Drawing (Isometric—Cabinet—Oblique)

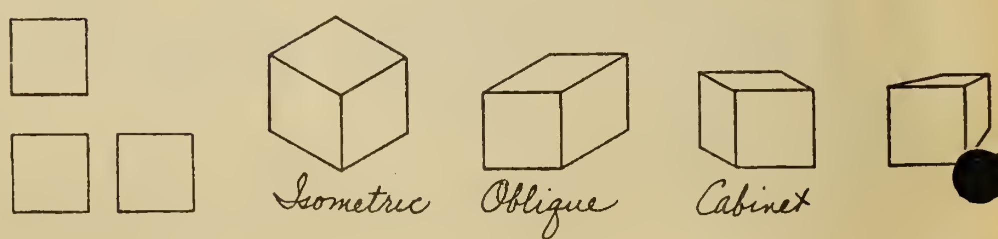
Score Value	*Exercise Number*	*Correct Answer*
(1)	1.	somewhat as it appears to the eye
(1)	2.	isometric lines
(1)	3.	non-isometric lines
(1)	4.	show in their true size
(1)	5.	taken along isometric lines
(½)	6.	cannot
(½)		locating their ends
(½)	7.	cannot
(½)		by locating the ends of the lines which form them

Score Value	*Exercise Number*	*Correct Answer*
(1)	8.	an ellipse
(1)	9.	directly at one face
(⅓)	10.	vertical
(⅓)		horizontal
(⅓)		any convenient angle
(1)	11.	facing the front
(1)	12.	are laid out
(½)	13.	a circle
(½)		an ellipse
(1)	14.	an oblique drawing
(1)	15.	furniture and woodwork
(1)	16.	are cut in half
(1)	17.	isometric axes

(10) 18–27. Score 1 for each isometric line checked, and also score 1 for each non-isometric line **not** checked. Highest possible score is 10.



(3) 28–30. Score 1 for each correct indication.



Class Record Sheet
Badger Mechanical
Drawing Tests

Published by the
Public School Publishing Co.
Bloomington, Illinois

Printed in U. S. A.

CLASS RECORD SHEET FOR A SERIES OF STANDARD TESTS IN FUNDAMENTAL MECHANICAL DRAWING

by

ALEX. J. BADGER,
Instructor, Mechanical and Architectural Drawing,
Lincoln High School, Los Angeles, California

City..State..

School..Teacher..

Grade in Drawing.............................Class.............................Date.............................

Final Score	Test 1	Test 2	Test 3
	No. Pupils	No. Pupils	No. Pupils
100			
95-99			
90-94			
85-89			
80-84			
75-79			
70-74			
65-69			
60-64			
55-59			
50-54			
45-49			
40-44			
35-39			
30-34			
25-29			
20-24			
15-19			
10-14			
5-9			
0-4			
Total			
Median			

Instructions for Class Record Sheet

Use a separate class record sheet for each class.

Arrange the papers for each class and each test according to the scores on the test, putting on top of each pile the paper having the highest score. Count the number of pupils having a score of 100, and enter the number of them in the proper "No. Pupils" column opposite "100". Proceed similarly to count the number of pupils having scores of 95, 96, 97, 98, and 99, and enter the number of them opposite "95-99". Continue in the same manner until all of the pupils' scores on each test are recorded.

Add the numbers just entered, and enter the sum for each column after the word "Total". The median is the score of the middle paper—if the number of papers is odd. If the number of papers is even, the median is the average of the scores of the middle two papers. For example, if 35 pupils took Test 1, the median score is that of the 18th paper. If 36 pupils took Test 2, the median for Test 2 is the average of the scores of the 18th and [illegible]th papers. The median may also be found by the statistical method (see any good book on statistics).

Standards

The standards for Tests 1, 2, and 3 are in preparation.

140-1p

Badger Mechanical
Drawing Test
TEST 1

Published by the
Public School Publishing Co.
Bloomington, Illinois
Printed in U. S. A.

Final Score..............................

A STANDARD TEST IN FUNDAMENTAL MECHANICAL DRAWING

by

Alex. J. Badger

TEST 1: Use of Tools - Linework - Dimensioning - Lettering

Name .... Date ....

School .... Teacher ....

Grade in Drawing.. Grade in School..

Tool Required: A medium soft pencil, well sharpened.

Directions: This test is intended as a check-up to see how much you know about the use of drawing tools, linework, dimensioning, and lettering. Work as rapidly as possible but do not hurry. Follow the printed instructions for each problem or group of problems carefully. Start now and perform each problem in its proper order and sequence; that is, first do exercise No. 1, then No. 2, etc.

In each of the following sentences, underline the word or words in parentheses which make the sentence correct.

Example: The T-square (should) (may) (<u>should not</u>) be used as a hammer to drive thumbtacks into the drawing board.

1. The T-square should be used with the head against (left) (right) (any) edge of the drawing board.

2. In ruling lines with the T-square, always use the (upper) (lower) (either) edge of the blade.

3. In using triangles with the T-square for ruling vertical lines, always have the vertical edge of the triangle towards the (right) (left) (either right or left).

4. A 4H pencil is (soft) (medium) (hard). A 2B pencil is (soft) (medium) (hard). An HB pencil is (soft) (medium) (hard). For sharp, accurate linework, a (4H) (2B) (HB) pencil is the best.

5. In starting a dotted line from a solid line, if the dotted line is a continuation of the solid line, the first short dash (should) (may) (should not) touch the solid line. If the dotted line is not a continuation of the solid line, the first short dash (should) (may) (should not) touch the solid line.

6. In inking lines with the ruling pen, always hold the pen with the set-screw (towards you) (away from you) (at right angles to you).

7. Guide lines (should) (need not) (should not) be drawn for every line of lettering.

8. Lettering guide lines should be (light) (either light or heavy) (heavy).

9. When lettering is inked, the guide lines should (be inked also) (be inked occasionally) (never be inked).

10. The symbol (′) indicates (inches) (feet) (yards). The symbol (″) indicates (inches) (feet) (yards).

11. Dimension and extension lines should be (light) (either light or heavy) (heavy).

12. Extension lines (should) (may) (should not) touch the drawing outline.

13. Extension lines should extend (about ½ inch past) (a little past) (to) the arrows on the ends of the dimension lines.

14. Dimensions (should read) (should sometimes read) (do not have to read) in line with the dimension lines in which they are written.

15. Dimensions should read from the (lower and left) (lower and right) (top and left) side of sheet.

16. In writing a fraction, the fraction bar should be (vertical) (slanting) (horizontal) and should be (above) (even with) (below) the dimension line.

17. In dimensioning, always give the (diameter) (radius) (either diameter or radius) of an arc; always give the (diameter) (radius) (either diameter or radius) of a circle.

18. A center line (should not) (may) (should always) be used as a dimension line.

19. A line of the object (should not) (may) (should always) be used as a dimension line.

20. Always dimension to the (center) (edge) (either center or edge) of a round piece or hole.

21. Dimensions (should be) (need not be) (should never be) repeated on every view of a working drawing.

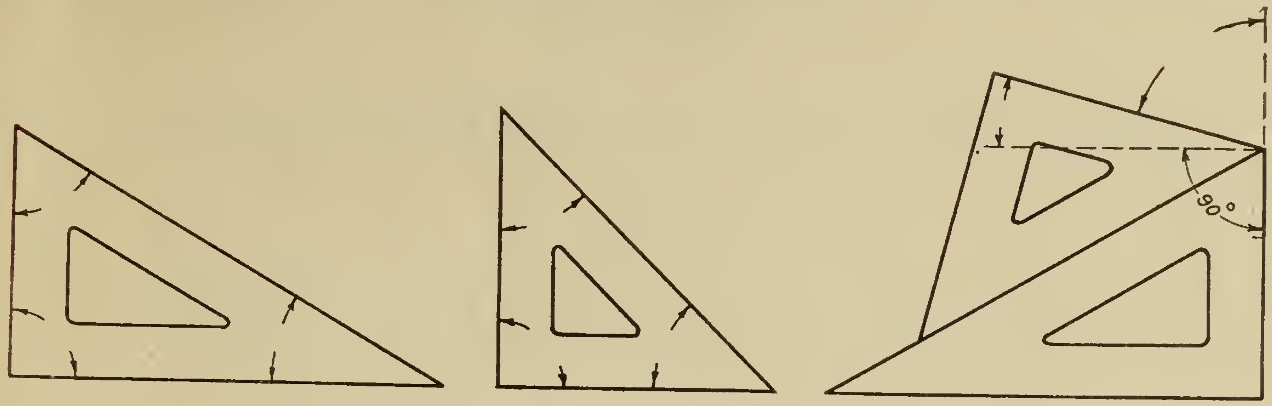
22. On a working drawing with two or more views, in placing dimensions pick out the view (which tells the most about the shape of the object) (which has the most lines in it) (which looks the best) and place all possible dimensions on that view, the remaining dimensions being placed on the other views.

23. On a working drawing with two or more views, place dimensions (at the right side of the views) (at the left side of the views) (between views) whenever possible.

24. Dimension lines (may cross) (should never cross) (should always cross) extension lines.

25. In filling the ruling pen with ink, put in (all the ink it will hold) (about ½ inch of ink) (about ¼ inch of ink.)

26-33. In the three accompanying drawings of triangles, fill in the correct number of degrees in each of the angles indicated.



34-38. Under each of the three lines, underscore the words which tell the one or more uses for which you think that particular weight of line is best suited.

Border line Main line Dimension line Extension line Center line

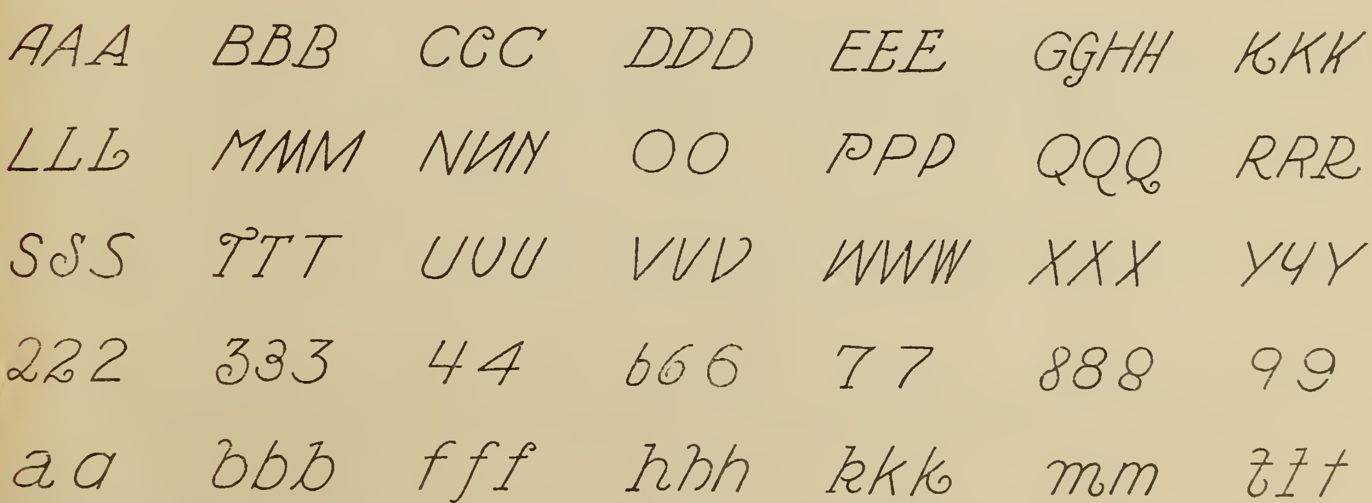
Border line Main line Dimension line Extension line Center line

Border line Main line Dimension line Extension line Center line

39. Place a check mark on the arrowhead which you think is the best type to use on dimension lines.

40-75. Place a check mark over the letter or figure which you think is the best of the several examples given of each. Place your check marks like the one that is shown in the example.

Example: r r r



Pupil's Score.. × 1⅓ = ...Final Score

Badger Mechanical
Drawing Test
TEST 2

Published by the
Public School Publishing Co.
Bloomington, Illinois
Printed in U. S. A.

Final Score ....

A STANDARD TEST IN FUNDAMENTAL MECHANICAL DRAWING

by

Alex. J. Badger

TEST 2: Projection, including Sections and Auxiliary Views

Name .... Date ....

School .... Teacher ....

Grade in Drawing .... Grade in School ....

Tools Required: A medium soft pencil, well sharpened, and a triangle.

Directions: This test is intended as a check-up to see how much you know about projection drawing, sections, and auxiliary views. Work as rapidly as possible but do not hurry. Follow the printed instructions for each problem or group of problems carefully. Start now and perform each problem in its proper order and sequence; that is, first do exercise No. 1, then No. 2, etc.

In each of the following sentences, underline the word or words in parentheses which make the sentence correct.

Example: Section lines should be <u>(evenly)</u> (unevenly) (either evenly or unevenly) spaced.

1. Projection drawing is the method of representing the exact form of an object (by showing a picture of it) (by a detailed description of it) (in two or more views placed in a certain relation to each other).

2. The projection method is the best method of making a working drawing because (it is the easiest method) (it looks the best) (it is the only method in which the exact forms and relations of the parts of the object can be shown) (it is the quickest method to use).

3. A section drawing of an object is (a drawing showing it in three views) (a view showing it as though it had been cut in two or more parts and the interior exposed) (a picture of it).

4. A section view is frequently necessary in order to (simplify the drawing work) (make the construction of the object more easily understood) (make the drawing look better).

5. In a section drawing, section lines are placed on any part of the object (which has been cut) (which has not been cut) (which makes the drawing stand out).

6. Section lines are generally drawn at an angle of (55°) (45°) (30°) (60°).

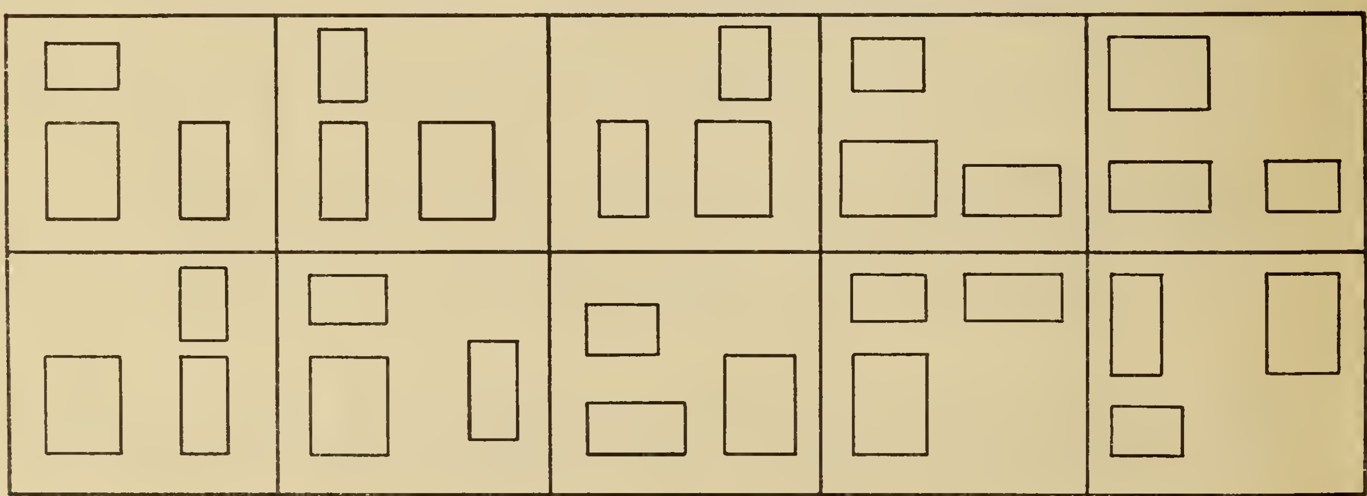
7. Section lines should generally be (fine) (heavy) (fine or heavy) lines.

8. An auxiliary view of an object is (an extra view which helps you to understand the shape of the object) (which adds to the appearance of your drawing although it is unnecessary) (a picture of the object in addition to the two or three view working drawing).

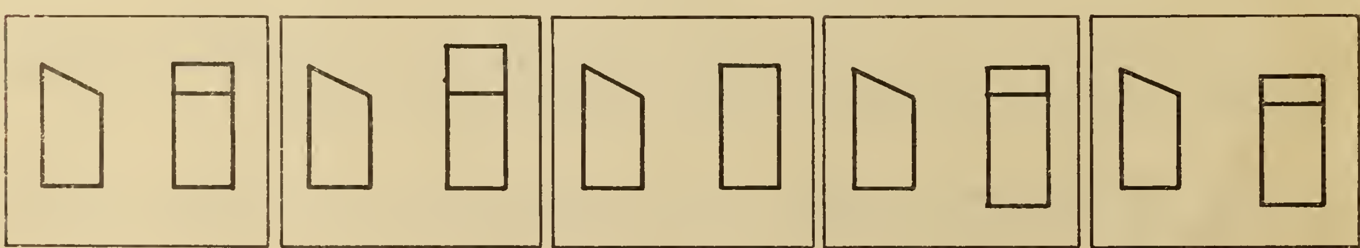
9. An auxiliary view is sometimes used in order to show a slanting surface of an object (in its true shape) (foreshortened) (so that it will fit better on the paper).

10. An auxiliary view is drawn by considering that you are looking at the slanting surface of the object in a direction (perpendicular to it) (at a 45° angle to it) (at any angle to it).

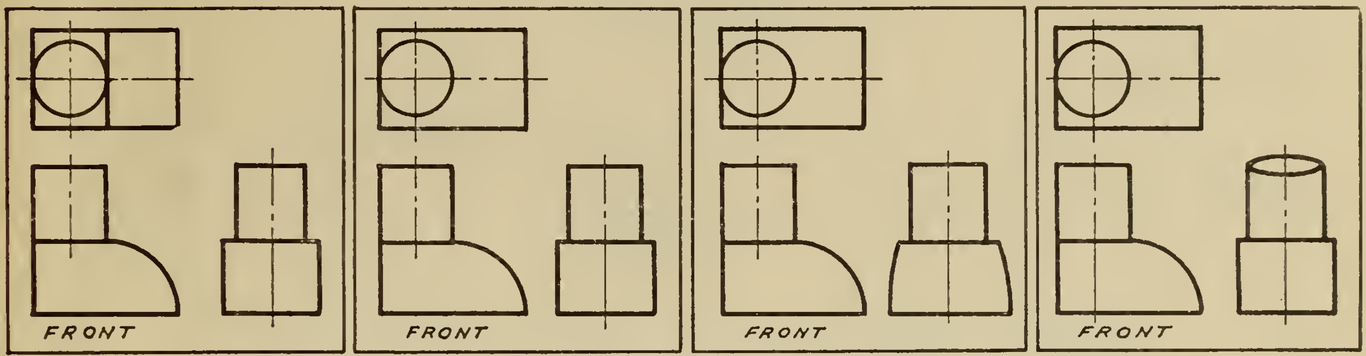
11-20. In the following group of three-view drawings, place a large check mark on each group in which you think the different views are placed in the proper relationship to each other.



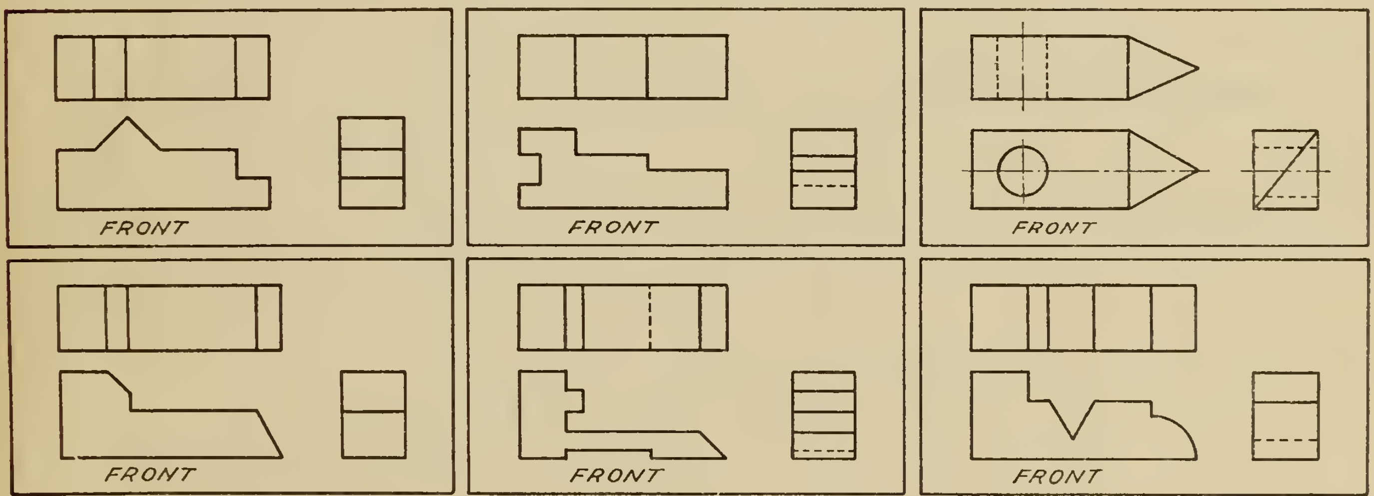
21-25. In the following group of two-view drawings, place a large check mark on the one or more right side views which are drawn correctly.



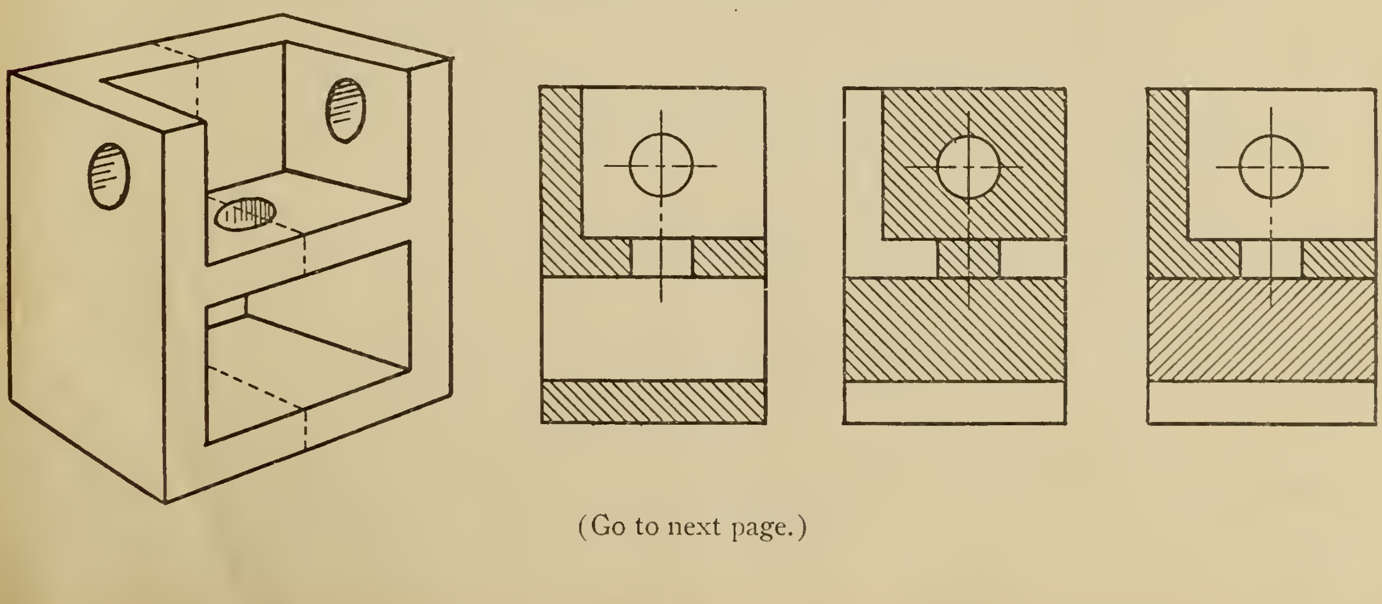
26-29. In the following group of three-view drawings, place a large check mark on the one or more groups which are drawn correctly. (The front view is drawn correctly in each case).



30-35. In the following group of three-view working drawings, there are a total of 6 lines (full or dotted) missing amongst the different views. Find and draw in these missing lines, using your triangle and pencil. (The front views are all correct as shown).

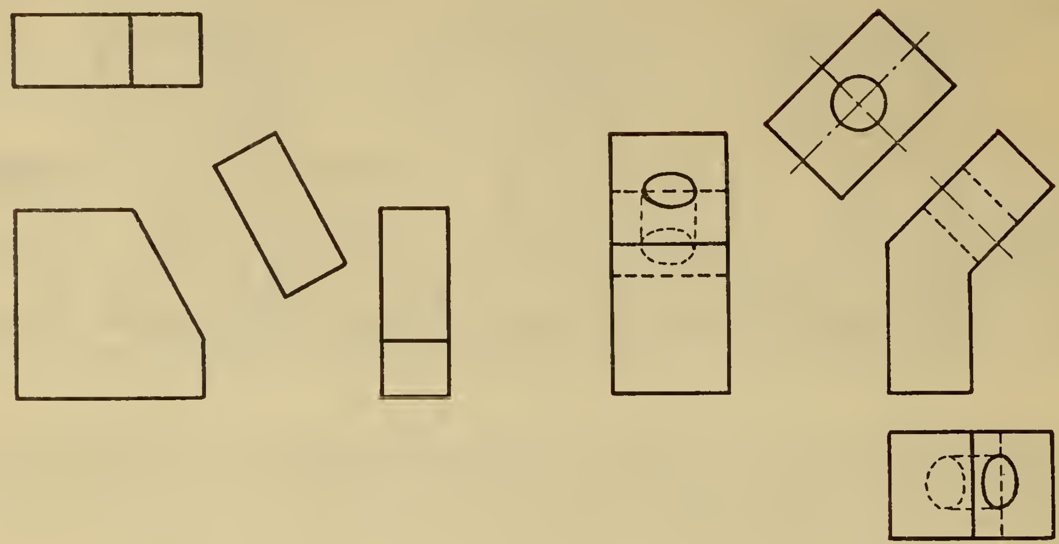


36-38. In the following group of drawings, place a large check mark on the one or more which are correctly drawn section drawings of the piece at the left. Consider that the piece has been cut as indicated by the dotted line and that you are looking at it from the left.



(Go to next page.)

39-40. In the following group of drawings, place a large check mark on each view which you think is an auxiliary view.



Pupil's Score.. × 2½ = ...Final Score

Badger Mechanical
Drawing Test
TEST 3

Published by the
Public School Publishing Co.
Bloomington, Illinois
Printed in U. S. A.

Final Score..

A STANDARD TEST IN FUNDAMENTAL MECHANICAL DRAWING

by

Alex. J. Badger

TEST 3: Pictorial Drawing (Isometric-Cabinet-Oblique)

Name ....Date ....

School ....Teacher ....

Grade in Drawing..Grade in School..

Tool Required: A medium soft pencil, well sharpened.

Directions: This test is intended as a check-up to see how much you know about isometric, cabinet, and oblique drawings. Work as rapidly as possible but do not hurry. Follow the printed instructions for each problem or group of problems carefully. Start now and perform each problem in its proper order and sequence; that is, first do exercise No. 1, then No. 2, etc.

In each of the following sentences, underline the word or words in parentheses which make the sentence correct.

Example: The same general rules for laying out measurements on an isometric drawing (are sometimes used) (<u>are used</u>) (are not used) in laying out an oblique drawing.

1. An isometric drawing of an object shows it (in two or more views) (exactly as it appears to the eye) (somewhat as it appears to the eye).

2. Lines which are parallel to any of the isometric axes are called (straight lines) (isometric lines) (non-isometric lines).

3. Lines which are not parallel to any of the isometric axes are called (straight lines) (isometric lines) (non-isometric lines).

4. In an isometric drawing, the principal edges (show in their true size) (show in approximately their true size) (do not show in their true size).

5. In laying out measurements on an isometric drawing, the measurements must all be (measured horizontally) (taken along isometric lines) (measured vertically).

666-4p

6. Non-isometric lines (can) (may) (cannot) be measured. They are located by (measuring them) (measuring them approximately) (locating their ends).

7. In laying out an isometric drawing, angles (can) (may) (cannot) be measured in degrees but must be drawn (with a protractor) (by locating the ends of the lines which form them) (by making them approximately correct).

8. In an isometric drawing, a circle appears as (a circle) (an ellipse) (a straight line).

9. In an oblique drawing, we consider that we are looking (at one edge) (directly at one face) (at one corner) of the object.

10. An oblique drawing is based on the three following axes: Underline the three which are correct,—(vertical) (horizontal) (45° angle) (30° angle) (60° angle) (75° angle) (any convenient angle).

11. In making an oblique drawing, always place the side of the object with the most irregular outline (facing the front) (at the top) (at an angle).

12. In an oblique drawing, most of the actual sizes of the object (are laid out) (are sometimes laid out) (are not laid out).

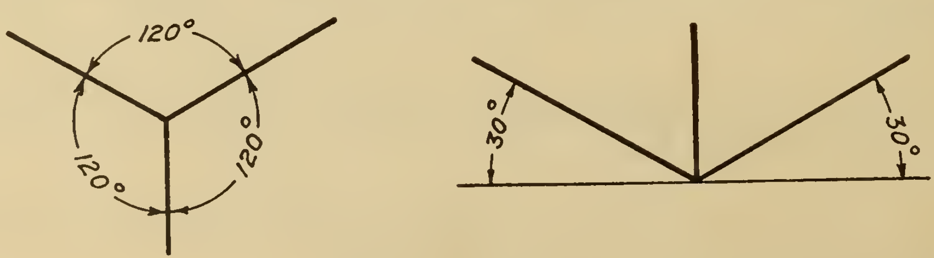
13. In an oblique drawing, a circle on the side of the object which is facing the front, will show in the drawing as (a circle) (an ellipse) (a straight line) and if on the top or side will show as (a circle) (an ellipse) (a straight line).

14. A cabinet drawing is most similar to a (projection drawing) (an isometric drawing) (an oblique drawing).

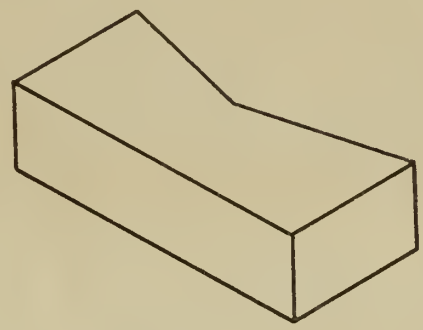
15 Cabinet drawing is used chiefly in drawings of (furniture and woodwork) (machine parts) (maps).

16. In a cabinet drawing, measurements made on the surfaces which appear at an angle are (shown in their true sizes) (are cut in half) (are doubled).

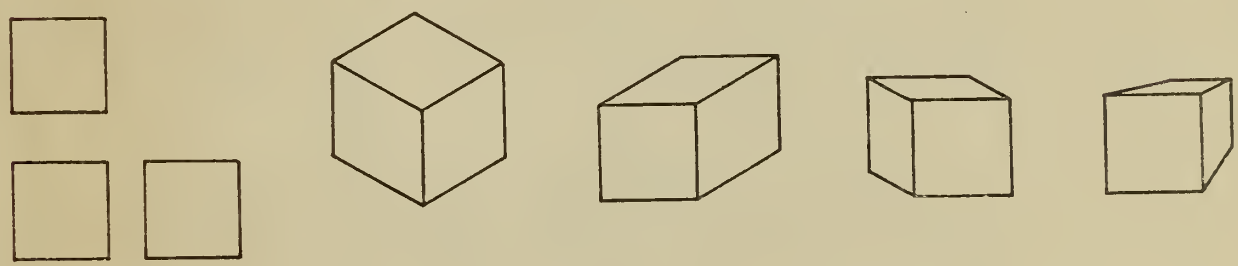
17. As the foundation for an isometric drawing, what name is given to the accompanying sets of lines? Write the name under them.



18-27. In the accompanying drawing, place a check mark on all lines which are called isometric lines.



28-30. Which one of the accompanying drawings is an isometric drawing? Which one is an oblique drawing? Which one is a cabinet drawing? Write the word "isometric," "oblique," and "cabinet" under the proper drawing of each.



Pupil's Score.. × 3⅓ = ...Final Score